ABEM

User Manual

Terraloc Pro

ABEM Product Number 33 700 89

ABEM 20161209, based on release 2.2.8 of SeisTW

Thank you for choosing ABEM Terraloc Pro

Trademarks

General information

Information in this manual is subject to change without notice and constitutes no commitment by ABEM Instrument AB.

ABEM Instrument AB takes no responsibility for errors in this manual or problems that may arise from the use of this material.

In general, e-mail correspondence gives the fastest response.

In view of our policy of progressive development, we reserve the right to alter specifications without prior notice.

ABEM will be pleased to receive occasional reports from you concerning the use and experience of the equipment. We also welcome your comments on the contents and usefulness of this manual. In all communication with ABEM be sure to include the instrument types and serial numbers.

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About This Manual

The conventions and formats of this manual are described in the following paragraphs:

- **Typographical conventions** used in this manual:

Italic	Names of objects, figure descriptions
Bold	In-line minor headers, emphasis
Blue Italic	URL links

- **Formats** used in this manual for highlighting special messages:

– Use of the internal keyboard is given in this format
– A sequence of steps will have two or more of these parts

Further information about this particular usage is given like this

Note!	This format is used to highlight information of importance or special interest

Warning!	Ignoring this type of notes might lead to loss of data or a malfunction

These notes warn for things that can lead to people or animals getting hurt or to equipment getting damaged

1 Get ready - Unpacking your new Terraloc® Pro

1.1 Welcome To Refraction, Reflection And Tomography

Welcome to the ABEM Terraloc®Pro, the multi-channel digital seismograph for cost-effective refraction and high-resolution reflection surveys, tomography, vibration measurements, and more, anywhere in the world in all weather conditions.

The basic Terraloc Pro is a self-contained multi-channel seismograph with internal PC-compatible computer, a hard disk and a daylight visible 8.4 " TFT color display with SVGA resolution. Operating power comes from an internal battery, or any external battery pack or power source that delivers from 10 - 30 volts DC. Typically this means a re-chargeable battery pack, a car (or truck) battery, or AC/DC power supply (office power supply unit). The inbuilt battery charger charges the internal battery pack when an external power source is connected.

The Terraloc Pro has a hard disk with a size of at least 100 GB. It also has 3 USB 2.0 ports, an Ethernet port and a VGA monitor port.

The physical dimensions are the same for all models, 12 – 48 Channels.

After a survey you may process data stored on the internal hard disk using Terraloc Pro internal PC or an external computer. Large amounts of data can be transferred between the Terraloc Pro and an external PC using the built in Ethernet port in the Terraloc Pro. For filtering and basic processing you can use the Terraloc Pro internal software called SeisTW, which is the software that controls the functions of the Terraloc Pro. Third party software packages for seismic data processing can be run directly on the Terraloc Pro. Please ask your authorized ABEM Distributor for details about the seismic interpretation and processing packages that are available.

Your Terraloc Pro was carefully checked at all stages of production. It was thoroughly tested before being approved for delivery. If you handle and maintain it according to the instructions in the technical documentation, you will get many years of satisfactory service from it.

1.2 Features of the ABEM Terraloc Pro

Examples of features of the ABEM Terraloc Pro are:

- SeisTW for Windows XP, ABEM developed measurement software (Included and factory installed)
- 3 USB ports for connecting external accessories such as USB CD/DVD, USB memory sticks, keyboard, mouse, card reader etc.
- Ethernet port for fast transfers of data and networking capabilities
- Daylight visible color 8.4" TFT SVGA display
- Excellent resolution thanks to a 24 bit ADC (analog/digital converter)
- In-field quality control of measurements thanks to geophone tests, noise monitoring, and a wide choice of single- or multi-trace view modes
- Excellent results for tomography and high resolution seismic thanks to selectable sampling rates from 25 µs to 2 ms in seven steps
- Full on-screen display of recorded traces with software roll-along, automatic pick of first arrivals, list of first arrival times, velocity calculation, frequency analysis of single traces.

1.3 The Delivered Instrument

Your Terraloc Pro arrives in a wooden transport box. Open it and unpack all items carefully. Check the contents of the box or crate against the packing list. If you ordered optional equipment, check the invoice/packing list for details and compare with your original order.

A standard ABEM Terraloc Pro system includes the following (*Figure 1*):

1 Terraloc Pro field unit with a number of channels as shown on the packing list

1 External power cable with connector and crocodile clips,
ABEM part no. 33 3000 42

1 Internal battery pack, ABEM part no. 33 3000 77

1 Office power supply unit, ABEM part no. 39 0450 08

1 Cable for office power supply, ABEM part no. 33 7000 58

1 External USB-Keyboard-Mouse Kit, ABEM part no. 33 5000 35

1 Trigger cable 250m on reel, ABEM part no. 33 0011 25, (packed in own box)

1 Terraloc Pro Accessories & Tools kit, ABEM part no.33001193 (small carton box) comprising:

- 2 2 m connection cables (for trigger coil) ABEM part no. 39 7101 04
- 1 Insulating tape roll
- 1 Engineer pliers
- 1 Pair of cutting pliers
- 1 Torx key T-20
- 1 Torx key T-25
- 1 Philips No.1 Screwdriver
- 1 Trigger coil, ABEM part no. 33 0011 26
- 1 LAN cable RJ45 connectors 5m (for Ethernet), ABEM no. 39 7101 69

1 Terraloc Pro Documentation kit ABEM part no. 33 5000 93, comprising:

- 1 Terraloc Pro Instruction manual
- 1 USB memory stick for software recovery
- 1 Warranty registration card

Figure 1 Standard Terraloc Pro system

1.4 Inspection

Inspect the instrument and accessories for loose connections and inspect the instrument case for any damage that may have occurred due to rough handling during shipment.

The instrument is delivered in a reusable plywood box. The box is designed to offer a convenient and safe transport option. All packing materials should be carefully preserved for future re-shipment, should this become necessary. Always make sure to use the transport box provided, or an alternative of at least equivalent mechanical protection and shock absorption whenever the instrument is shipped.

1.5 Shipping Damage Claims

File any claim for shipping damage with the carrier immediately after discovery of the damage and before the equipment is put into use. Forward a full report to ABEM, making certain to include the ABEM delivery number, instrument type(s) and serial

number(s). If it is a question of short shipment you must make a claim in writing to ABEM within 14 days of your receipt of shipment.

1.6 Shipping/Repacking instructions

The ABEM packing kit is specially designed for the Terraloc Pro. The packing kit should be used whenever shipping is necessary. If original packing materials are unavailable, pack the instrument in a wooden box that is large enough to allow some 80 mm of shock absorbing material to be placed all around the instrument. This includes top, bottom and all sides. Never use shredded fibers, paper or wood wool, as these materials tend to pack down and permit the instrument to move inside its packing box. **Please read our shipping instructions before returning instruments to ABEM. The instructions can be found on our website.** For further assistance please contact ABEM or its authorized distributor. Contact information can be found in the beginning of this document.

1.7 Registration

When you have checked the packing list, the next important thing to do is to register your Terraloc Pro. To register send an email with your contact information to *support@guidelinegeo.com*. Once registered, you will able to receive software updates and product information.

1.8 Take Time to Read The Technical Documentation

To ensure you get optimum results with the ABEM Terraloc Pro, please take time to read this instruction manual thoroughly. If you should, for any reason, have difficulties in operating ABEM Terraloc Pro or in getting satisfactory seismic survey results, please contact your authorized ABEM distributor. ABEM always listens to end-user comments about their experience with ABEM products. So please send occasional reports on field usage as well as your ideas on how the Terraloc Pro and its technical documentation can be improved to help you do an even better job of seismic surveying.

1.9 Software

Terraloc Pro is delivered with all necessary software installed at the factory. If the software needs to be updated, or re-installed, the procedure is described in 11 Appendix C. SeisTW Installation.

What is SeisTW?

SeisTW (***Seis***mograph ***T***erraloc ***W***indows) is a Windows XP application that is used to control the Terraloc Pro. It can also be installed on any PC running Windows XP and used to view and manage seismic records. However, when installed on a PC all functions accessing the Terraloc Pro hardware will be disabled.

SeisTW is included and factory installed in all Terraloc Pro instruments.

2 Overview of the Instrument

2.1 The Connector Panel

All connectors except for the external power are situated on the right side panel of the Terraloc Pro (Figure 2). Some of the connectors are described in more detail in chapter 10 Appendix B. Connectors.

Note!	Always have the connector protection dust caps in place whenever a connector is not used

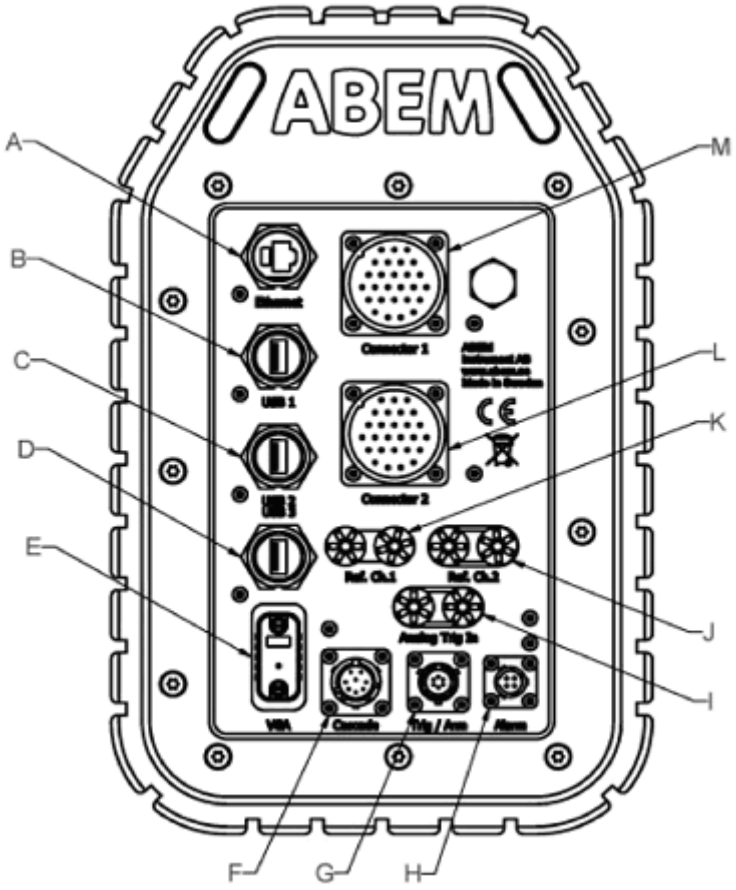


Figure 2 The Connector panel

The connectors:

Label	Function
A	Ethernet
B	USB 1
C	USB 2
D	USB 3
E	VGA
F	Cascade
G	TTL Trig/Arm: To connect two or more Terraloc Pro as Master and Slave(s), for radio shot, and vibrator hand-shaking. Mating connector: see 10.3 TTL Arm/Trig Connector
H	Alarm: This connector can activate alarm units
I	Trigger input: for a trigger geophone shot instant contacts, a wire loop around the explosive charge, or trigger output from a mechanical energy source. Mating connectors: 4 mm banana plug or bare wire
J	Reference channel 2: (up hole channel). Connector for a single geophone or vibrator reference (signature). Mating connectors: 4 mm banana plug or bare wire
K	Reference channel 1: (up hole channel). Connector for a single geophone or vibrator reference (signature). Mating connectors: 4 mm banana plug or bare wire
L	Signal: for connecting geophone spread cables to channel 13-24 (24-channel) or 25-48 (48-channel). The connector is wired to industry standard. For wiring and mating connector: see 10.1.1 12 and 24 Channel Terraloc Pro and 10.1.2 48 Channel Terraloc Pro
M	Signal: for connecting geophone spread cables to channel 1-12 (24-channel) or 1-24 (48-channel). The connector is wired to industry standard. For wiring and mating connector: see 10.1.1 12 and 24 Channel Terraloc Pro and 10.1.2 48 Channel Terraloc Pro

2.2 The Power Panel

The power panel of the Terraloc Pro is shown in Figure 3. The Power Input connector is described in more detail in chapter 10 Appendix B. Connectors.

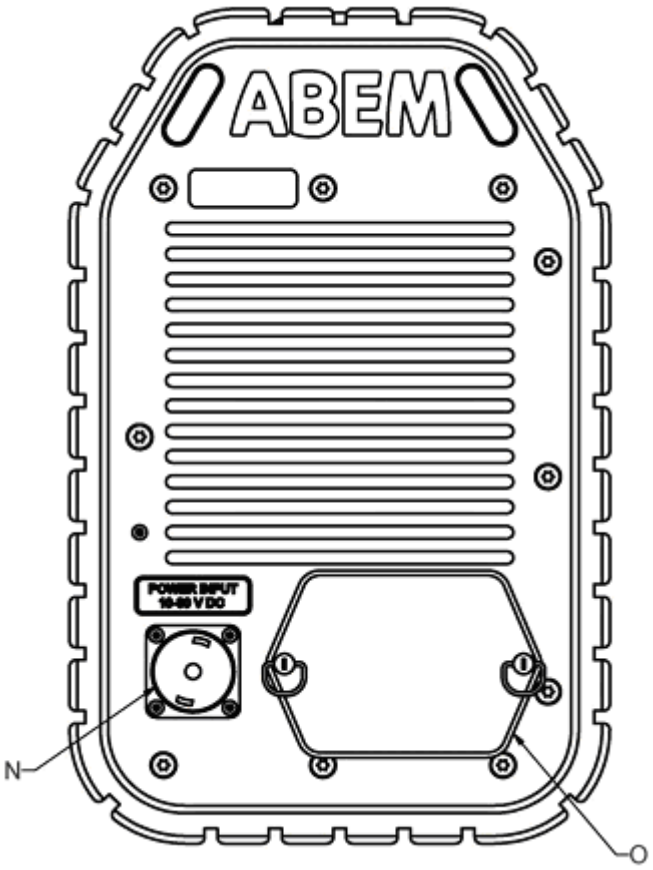


Figure 3 The Power panel

The connectors:

Label	Function
N	Power Input: for connecting an external power source. For wiring and mating connector see chapter 10.2 and for specifications see chapter 1 Use External Power cable with clips for a car battery, or Office power supply unit with Cable for office power supply
O	Internal battery lid

2.3 The Built-in GPS Receiver

Terraloc Pro has a built-in GPS receiver (Figure 4). In order to function well the built-in antenna in the handle of the instrument must be able to receive signals from a sufficient number of satellites. This will normally not function indoors and in outdoor areas with limited viewing angle towards the sky the function can be limited, for example in a forest. Positioning data is automatically saved in the header of the current record. The GPS receiver status is shown on the display (see chapter 4.4.8 Application Status Bar).

Figure 4 The GPS antenna is integrated in the left side of the handle

2.4 The User Interface Panel

All interaction with the Terraloc Pro is done through the user interface panel. *Figure 5* points out the parts of the user interface panel.

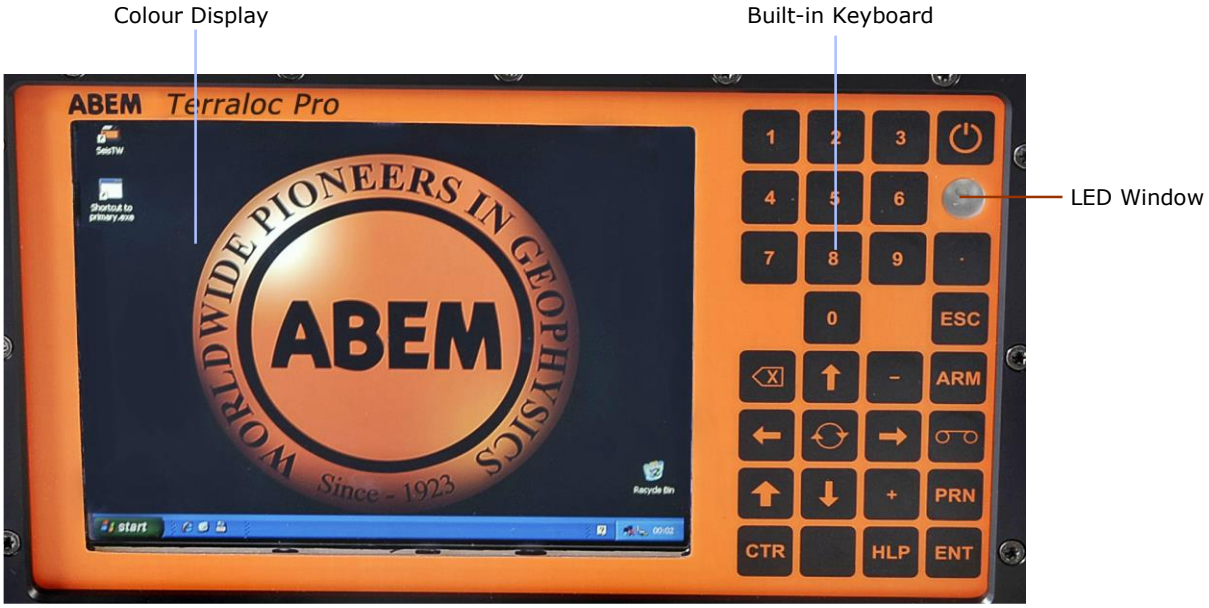


Figure 5 The user interface panel

There are two LED's shown through the *LED Window*:

- The green LED indicates disk activity
- The yellow LED indicates if sampling is on or off

2.5 The Power Supply

The Terraloc Pro can use an external power source as well as an internal battery as power supply. The external source can be a battery or a PSU (Power Supply Unit). If possible use the supplied cable set for the external power source. Both external and internal power sources can be attached at the same time. In this case the internal battery will be charged if the external battery is charged enough. The power supply status is shown on the display (see chapter 4.4.8 Application Status Bar).

For field operations a good, adequate in capacity and recently charged battery is vital for the best performance. It is possible to fully run the Terraloc Pro without the internal battery but for your convenience you should always have one installed.

The internal battery is primarily designed as a backup power source for operating the instrument during set up, data transfer etc, hence it cannot be used alone to power the instrument for a days work. It has quite a snug fit in the battery compartment. If the protective liner that keeps the cells together is found defective during inspection, please contact ABEM support for further information.

Once the instrument has been turned on and the external battery for any reason is disconnected the instrument will automatically switch to the internal battery. This useful feature makes it possible to disconnect the external battery temporarily without shutting off the instrument when for instance moving from one place to another.

2.6 Interconnecting Two or More Instruments

Should more channels be needed than can be supplied by the use of a single instrument, it is possible to connect (virtually) any number of Terraloc Pro instruments. The Arm, Disarm, and Trigger events can be synchronized with interconnected instruments. The TTL Arm/Trig connector is used to connect the instruments, see chapter 10.3.

Figure 6 shows an example from a survey where four Terraloc Mk6 were used to comprise a 96-channel system. The same can be done with Terraloc Pro instruments.

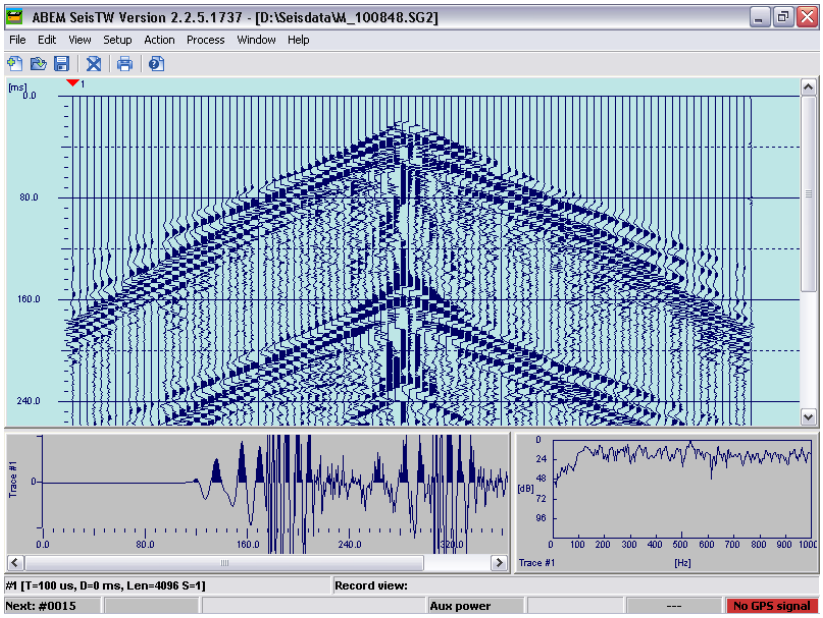


Figure 6 96-channel record, made using four interconnected Terraloc Mk6

3 Quick Start

In this section we will make a measurement of noise. It will give you an insight to how easy it is to set your Terraloc Pro up for operation. You will need no more equipment than the instrument itself and the power supply. However, before starting any fieldwork it is wise to invest time to go through and familiarize yourself with the various menus, dialogs and options that exist. These are described in detail in the following chapters. Should you feel uncertain during any of the steps below you can press <HLP> to get access to the help screen for explanations about which key command does what.

Now follow these steps:

- Connect the power supply (see Figure 3 connector N) and switch on the instrument by pressing <POWER>
- Some diagnostic messages show up on the screen during the start up tests and then Windows XP is started
- SeisTW starts automatically
- Press <ARM> to create a new acquisition record using the last active acquisition mode. To verify/change the acquisition settings press:

  <1> for Acquisition setup

  <2> for Trig setup

  <3> for Noise monitor

  <4> for Acquisition (analog) filters

  <5> for Receiver spread

  <6> for Layout geometry

  <7> for Header information (job ID, line ID, notes, etc.)

Note!	The built-in keyboard cannot be used to input text. For this an external USB-keyboard is needed

  <9> for View options (trace style, time compression, scale factor)

- Now press <ARM> again. This arms the instrument and makes it ready to trigger and record a trace. The status bar (at the bottom of the screen) displays the message “<<<ARMED>>>”
- Press <CTR> + <ARM> to force the instrument to trig. The message "<<< TRIGGERED >>>" is displayed in the status bar, shortly followed by “Transferring data…”, “Data in memory” and then “<<<ARMED>>>”.
- The recorded data is displayed in the three frames at the center of the screen. To change view options, press <9>
- Trigging once more by pressing <CTR> + <ARM> will replace the traces on the screen with a new set that looks a little bit different. What you see now is the average of the two measurements made so far

- Press <SAVE> to save the data (the message “No data” will be displayed) or press <ESC> to disarm the instrument (the message “Data in memory” will be displayed)
- When you are finished getting acquainted with the instrument, you may shut it down. Press <CTR> + <SPACE> for the quick menu and select "Power Off" among the menu items. Press <ENT> when the confirming dialog appears
- Now you should have learned a little about how to operate the instrument. Do not be afraid to test different settings and modes. There is no risk of causing any damage. Should you somehow get problems with the Terraloc Pro software SeisTW, it can be reinstalled (see 11 Appendix C. SeisTW Installation)

4 The User Interface

The user interacts with the instrument through the User Interface Panel and possibly connected USB input devices. This chapter explains the basics of this interaction.

4.1 The Display

SeisTW will normally be shown on the display. Figure 7 shows a normal start-up view of the SeisTW window.

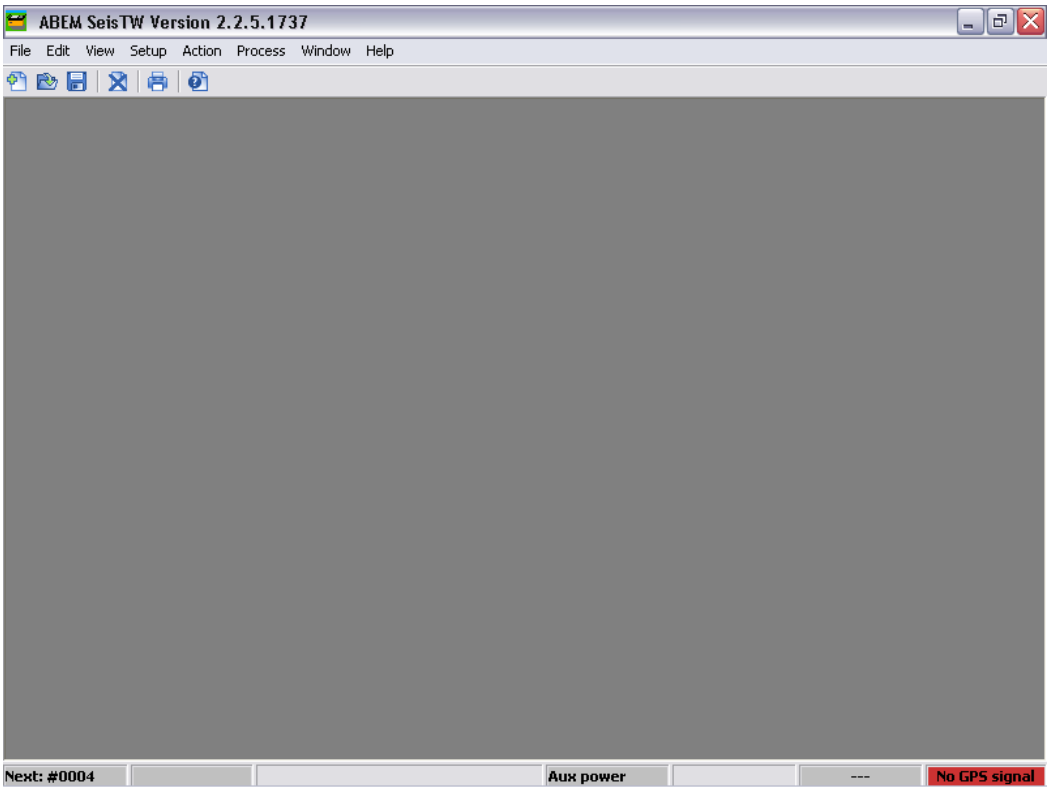


Figure 7 The SeisTW main window

For more information about the layout parts of SeisTW please see chapter 4.4.

4.2 Keyboard and Mouse

Commands from the user are entered through a keyboard and/or a mouse. There is a built-in keyboard (see *Figure 5*) but an external USB keyboard can also be used and as well an external USB mouse.

4.2.1 The Built-in Keyboard

Table 1 lists the names of the buttons as referenced in this document.

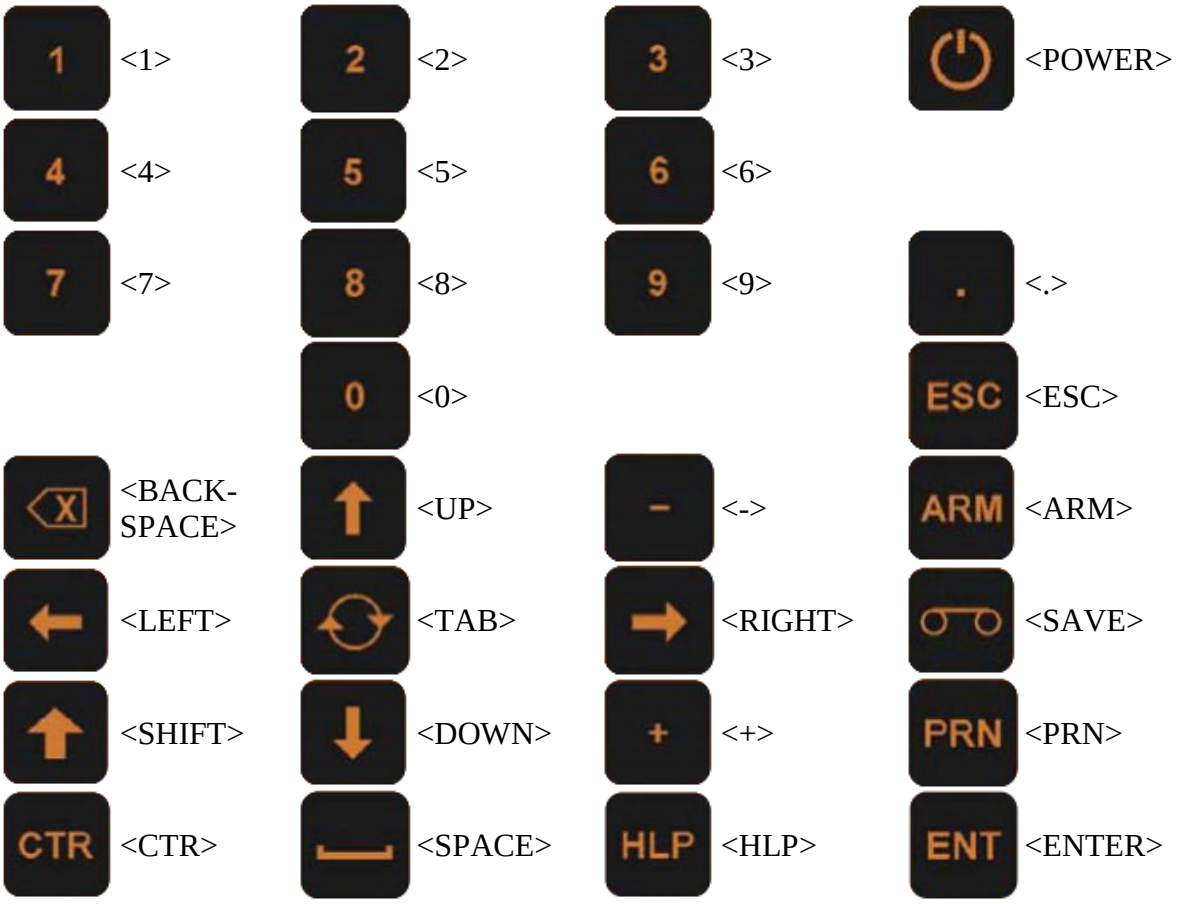


Table 1 Names used for the built-in keyboard buttons

Note!	Where <ARROWS> is used in the text it means all four arrow keys (up, down, left and right) Where <NUMBERS> is used in the text it means all numerical keys (0-9)

Note!	The <UP> and <SHIFT> keys are similar in appearance but the arrow of the <SHIFT> key is wider

4.2.2 An External Keyboard

A standard USB computer keyboard can be connected to one of the USB ports of the Terraloc Pro and used as a complement to the built-in keyboard. The mapping between the built-in buttons and the computer keyboard is listed in Table 2.

Note!	The only way to enter and edit text is to use an external keyboard

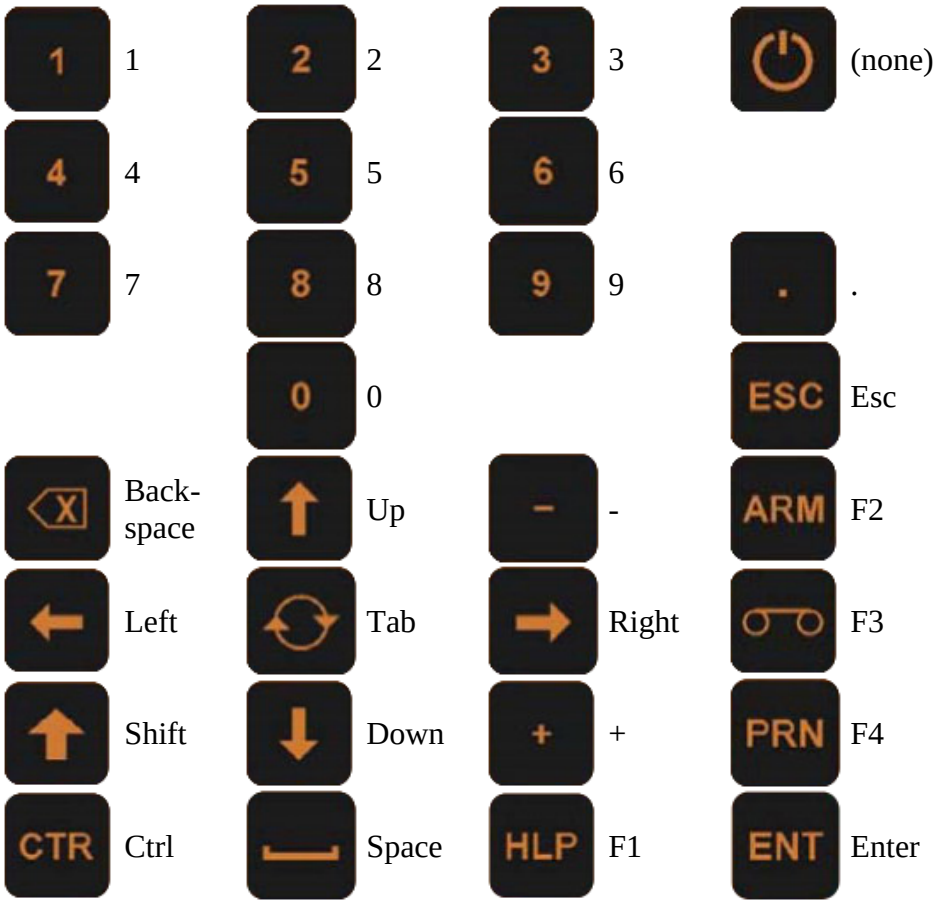


Table 2 Mapping between built-in keyboard and external keyboard

4.2.3 An External Mouse

A standard USB mouse can be connected to one of the USB ports of the Terraloc Pro and used as a normal mouse in the Windows XP environment.

4.3 Using SeisTW

SeisTW is a normal Windows program and using the program with external keyboard and mouse is like using any other Windows program. However using the built-in keyboard naturally brings with it some limitations. Some measures have been taken within SeisTW to remedy this and the rest of this chapter explains some of the more general of these measures. More information about the use of the built-in keyboard can be found in the chapters that describe the various functions of SeisTW. Please see Figure 13 on page 23 for a descriptive overview of the layout of SeisTW.

- Highlighting different views (*Record View – Trace View – Frequency View*). This is useful for working with the different views

  – Press <TAB> to highlight the next view

  – Press <SHIFT> + <TAB> to highlight the previous view

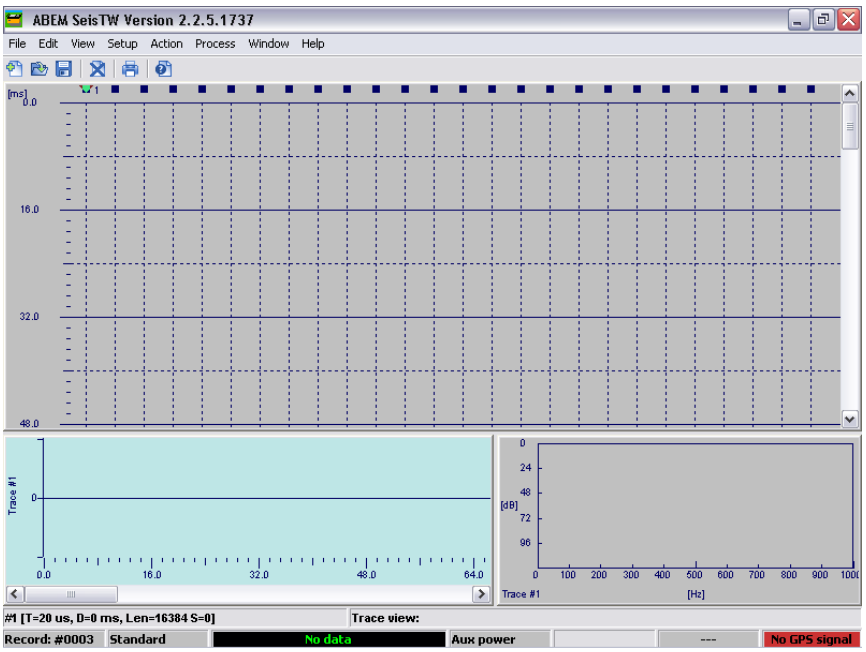


Figure 8 SeisTW with the Trace View highlighted

- Changing the sizes of the views. That is, moving the separators between the views (Figure 9 and Figure 10)

  – Press <CTR> + <UP> to move the horizontal separator upwards

  – Press <CTR> + <DOWN> to move the horizontal separator downwards

  – Press <CTR> + <LEFT> to move the vertical separator to the left

  – Press <CTR> + <UP> to move the vertical separator to the right

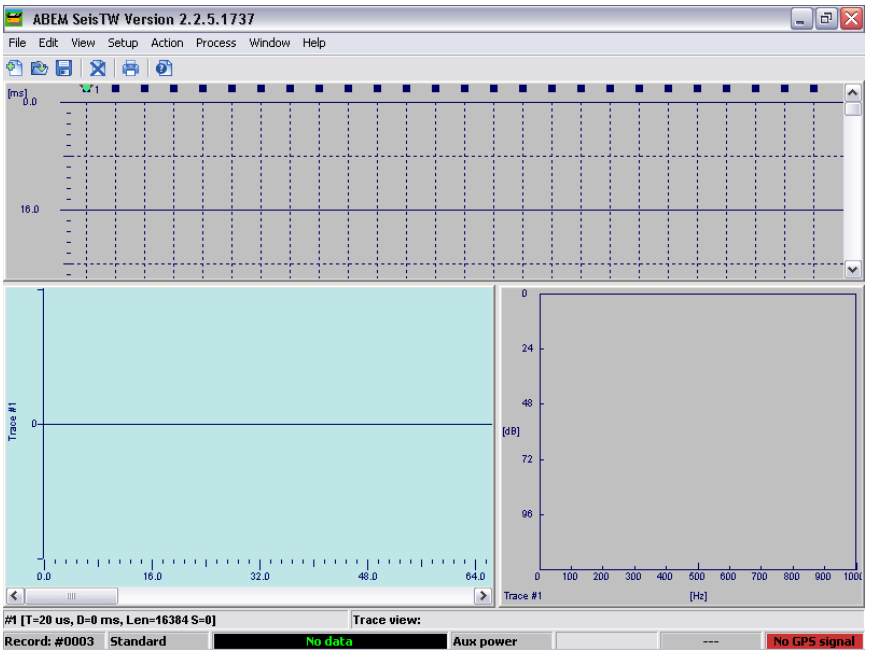


Figure 9 SeisTW with the horizontal separator moved upwards

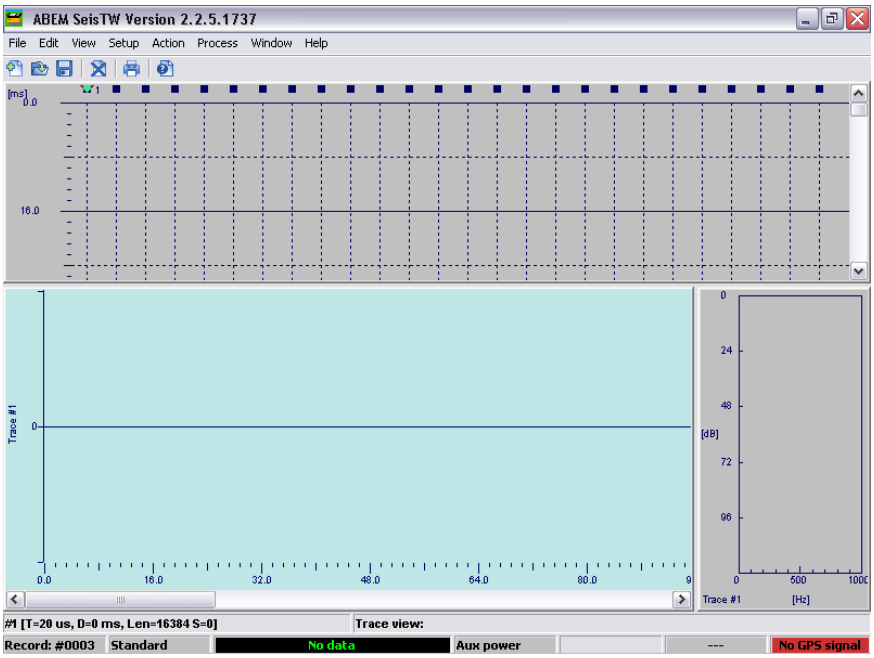


Figure 10 SeisTW with the vertical separator moved to the right

- Hiding the *Trace* and *Frequency Views.* The *Record View* will enlarge to cover the hidden area

  – Press <SHIFT> + <0> to alternately hide and show the two views

- Showing or hiding the *Logging Window*.

  – Press <SHIFT> + <SPACE> to alternately hide and show the *Logging Window*

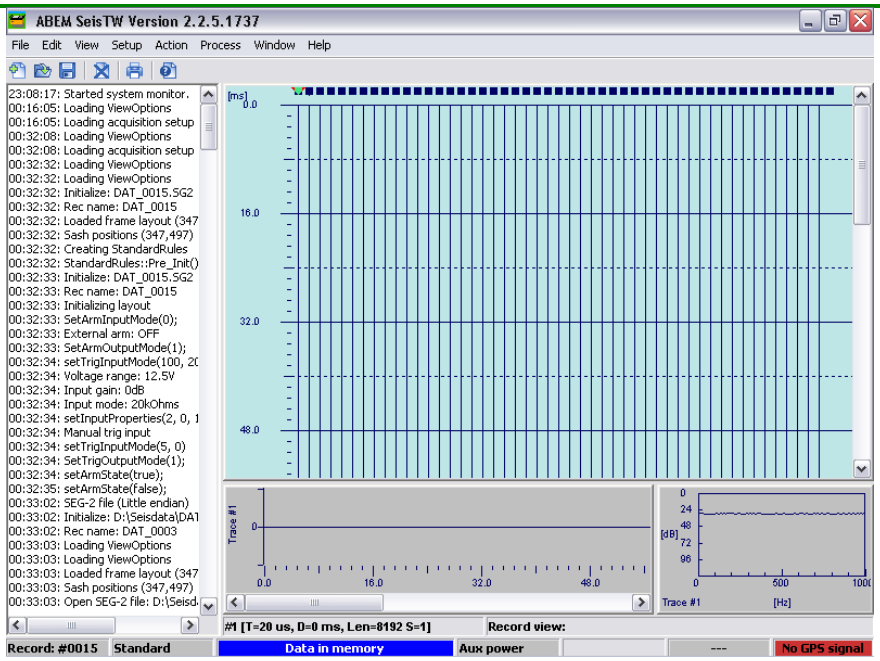


Figure 11 The Logging Window on the left side

- Opening and stepping through *Menu Bar* items

  – Press <CTR> + <BACKSPACE> to set focus on the *Menu Bar*

  – Press <DOWN> to open the *File* menu list

  – Press <DOWN> or <UP> to highlight a menu item

  – Press <LEFT> or <RIGHT> to open another top level menu list

  – Press <ENT> to execute the highlighted menu item

  Or, if a record is opened or created

  – Press <SPACE> two times (the first opens the *Context Menu* and the second opens the *System Menu*)

  – Press <RIGHT> and the *File* menu list is opened

  – Press <ARROWS> as described above to select the wanted menu item

- Navigating between input fields on dialogs

  – Press <TAB> to highlight the next input field

  – Press <SHIFT> + <TAB> to highlight the previous input field

- Changing settings on dialogs.
  The way to change a setting depends on the type of input field. See Figure 12 for examples of input field types

  – Drop-down list (see *Trig input mode*):
  Press <PRN> to open the list
  Press <PRN> again to close the list
  Press <UP> or <DOWN> to change the value

  – Track-bar (see *Trig input level*; Trig input mode must be Analog or Channel):
  Press <LEFT> or <RIGHT> to change the value

  – Check-box (see *Ext. arm verify*):
  Press <SHIFT> to change the value

  – Up-down field (see *Verify timeout [ms]*):
  Press <UP> to increment the value with 1
  Press <DOWN> to decrement the value with 1
  Press the <NUMBERS> keys to directly enter digits
  Press <BACKSPACE> to delete the digit before the input marker

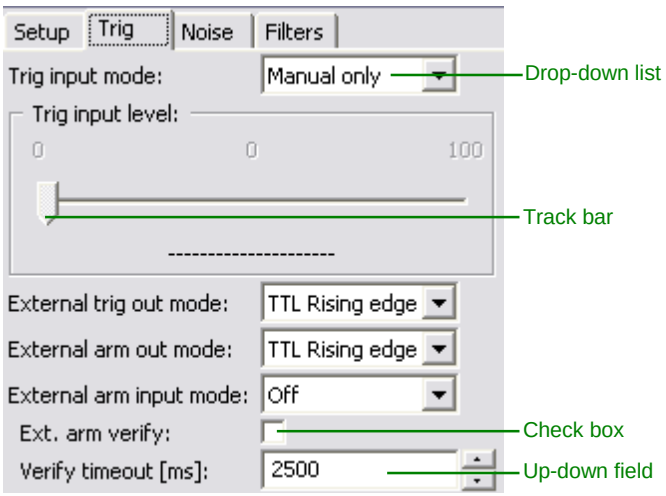


Figure 12 Part of Trig setup dialog as input field example

- Closing an opened dialog

  – Press <ENT> to close the dialog and save possible changes

  Or

  – Press <ESC> to close the dialog without saving possible changes

4.4 SeisTW Layout Parts

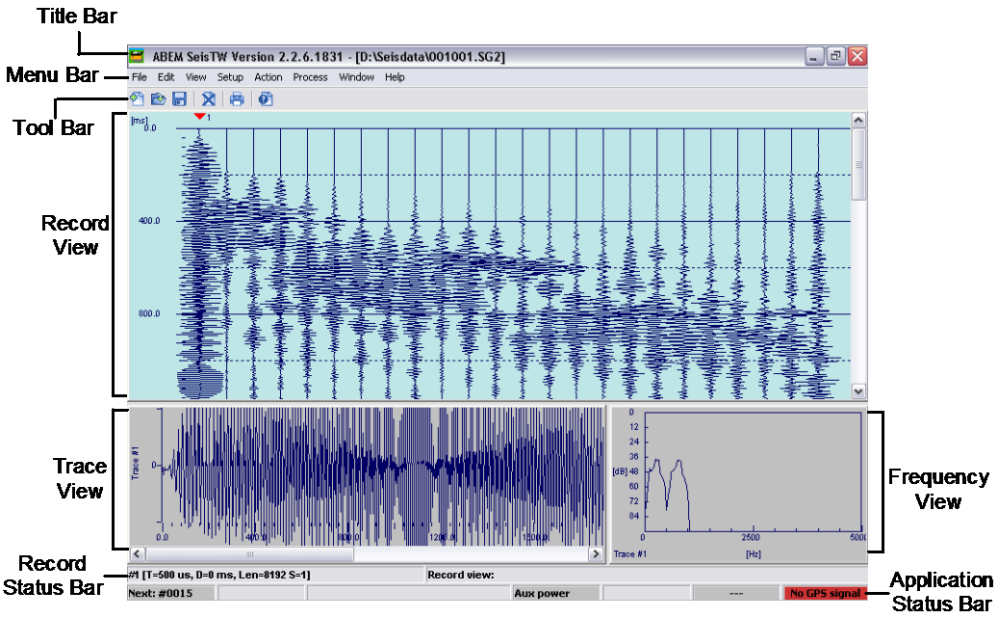


Figure 13 The SeisTW layout

The purpose and specific functions of each layout part will be described below.

4.4.1 Title Bar

The *Title Bar* displays the application name and version. It will also display the file name of an open record.

4.4.2 Menu Bar

The *Menu Bar* presents the main menu items to the user. Some of the displayed short cuts on the menu items are only applicable to an external keyboard.

4.4.3 Tool Bar

The *Tool Bar* presents the user with some buttons for actions that can be performed.

- Hide or show the *Tool Bar*.

  – Press <SHIFT> + <1> to alternately hide or show the *Tool Bar*

Hiding the tool bar will free more of the screen area for displaying data.

4.4.4 Record View

The *Record View* shows all traces vertically. A time scale is displayed on the left side. This timescale adjusts according to sample interval and view options. Tic lines across the screen (Figure 14) can be enabled in the View options dialog (see chapter 4.6.13).

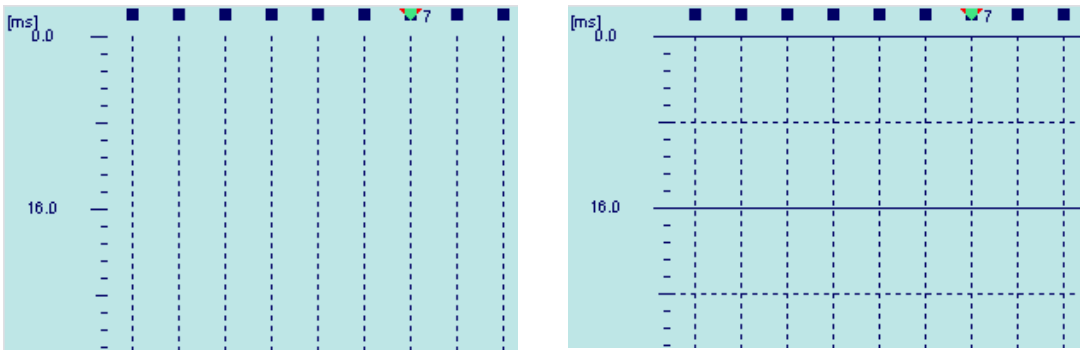


Figure 14 The Record View; Left: without Tic lines Right: with Tic lines

At the top of the view there is a trace marker. This marker points out the current trace, which is the trace that is shown in the *Trace* and *Frequency Views* (Figure 15).

Figure 15 Trace Marker; Left: For an opened record file Right: For a new record

- Moving the *Trace Marker* between traces
  - Press <LEFT> to move the marker to the previous trace or from the first to the last trace (wrap around)
  - Press <RIGHT> to move the marker to the next trace or from the last to the first trace (wrap around)
  - Press <SHIFT> + <LEFT> to move the marker to the first trace
  - Press <SHIFT> + <RIGHT> to move the marker to the last trace

When a record has been created the top of the view also displays the current Stack On status, and polarity. The Stack On is displayed by squares above each trace (Figure 16). If the square is filled the stack for that trace is on, and if the square is open, the same stack is off (see chapter 4.6.5.1 for information about the stack function). If negative polarity has been selected for a trace, a minus sign is displayed under the square (Figure 17).

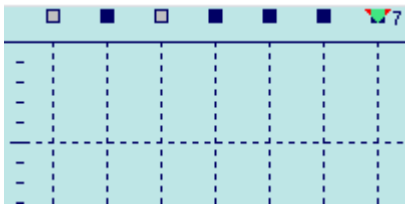


Figure 16 Stack On Status; Traces 1 and 3 are off

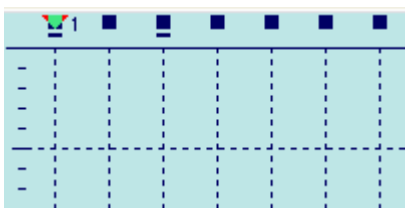


Figure 17 Negative Polarity; Traces 1 and 3 have negative polarity

- Scrolling the view

  – Press <UP> to scroll the view upwards
  – Press <DOWN> to scroll the view downwards
  – Press <SHIFT> + <UP> to scroll the view upwards a whole page
  – Press <SHIFT> + <DOWN> to scroll the view downwards a whole page

A timeline can be moved across the view. The time and A/D-value for the current trace and timeline position will be displayed in the status field just below the views. The timeline can be used to position a first break marker at the location of the timeline on the current trace.

- Moving a timeline across the view (Figure 18)

  – Press <+> to move the timeline downwards
  – Press <-> to move the timeline upwards
  – Press <SHIFT> + <+> to move the timeline downwards with a large step
  – Press <SHIFT> + <-> to move the timeline upwards with a large step

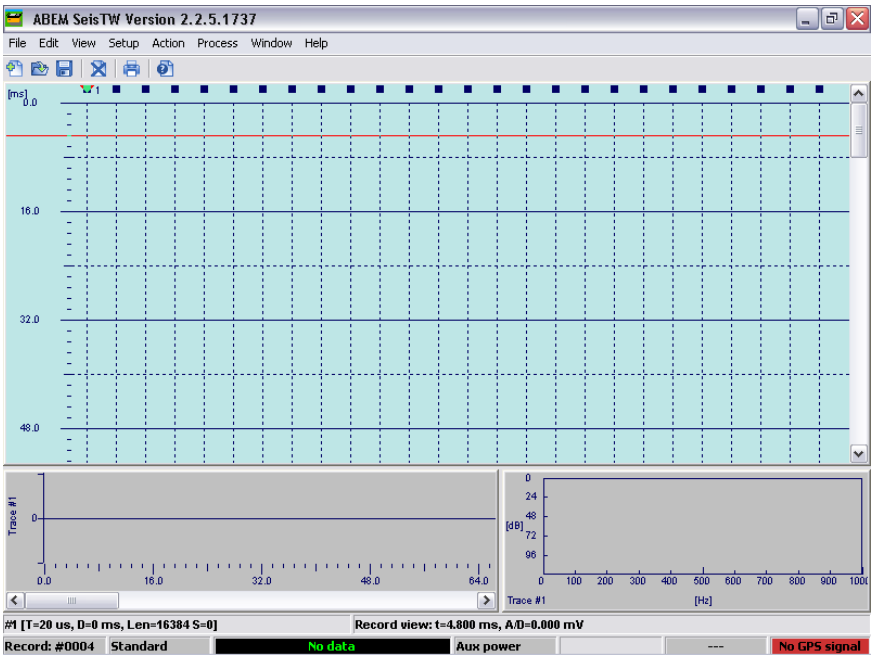


Figure 18 The red timeline

Note!	Keeping the key pressed will accelerate the movement of the timeline

- Positioning a first break marker (Figure 19)

  – Press <.> to position a first break marker. The marker will be positioned on the current trace. A similar marker is also positioned in the *Trace View*

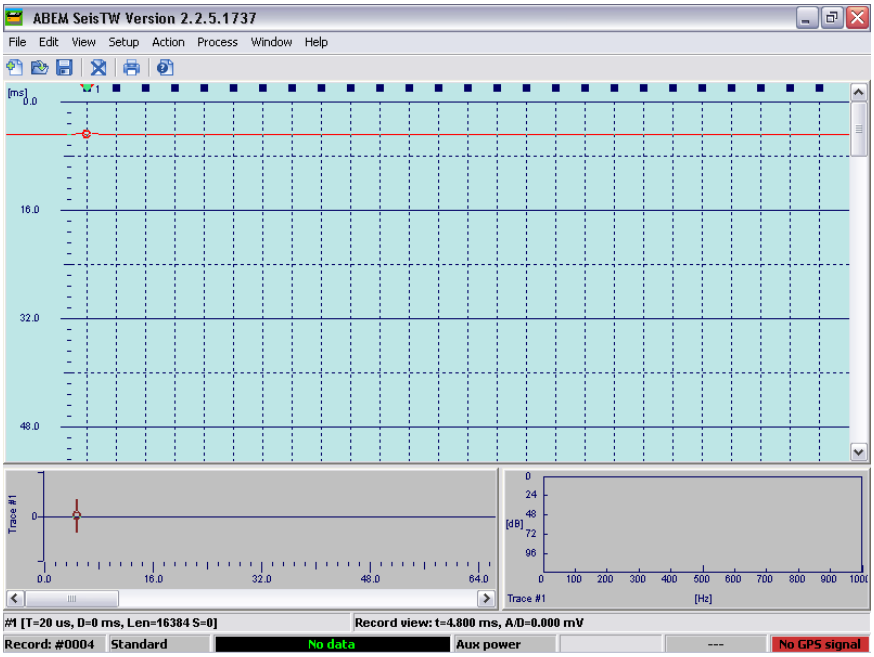


Figure 19 First break marker

- Positioning a first break marker on trace 2 (Figure 20)

  – Press <RIGHT> to select trace 2
  – Press <.> to position a first break marker

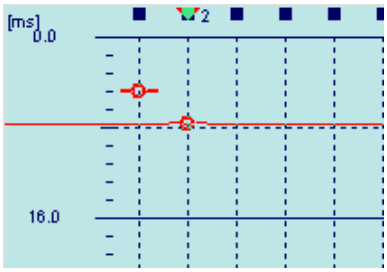


Figure 20 First break marker on trace 2

- Removing an existing first break marker

  – Select the wanted trace by pressing <LEFT> and/or <RIGHT>
  – Press and hold <-> until the timeline is invisible
  – Press <.> to remove the first break marker

4.4.5 Trace View

The trace view displays an enlarged view of the current trace and its frequency content.

- Change the trace to view

  – Press <UP> to change to the next trace

– Press <DOWN> to change to the previous trace

- Scrolling the view

– Press <LEFT> to scroll the view to the left
– Press <RIGHT> to scroll the view to the right
– Press <SHIFT> + < LEFT > to scroll the view to the left a whole page
– Press <SHIFT> + < RIGHT > to scroll the view to the right a whole page

A timeline can be moved across the view. The time and A/D-value for the current trace and timeline position will be displayed in the status field just below the views. The timeline can be used to position a first break marker at the location of the timeline on the current trace.

- Moving a timeline across the view (Figure 21)

– Press <+> to move the timeline to the right
– Press <-> to move the timeline to the left
– Press <SHIFT> + <+> to move the timeline to the right with a large step
– Press <SHIFT> + <-> to move the timeline to the left with a large step

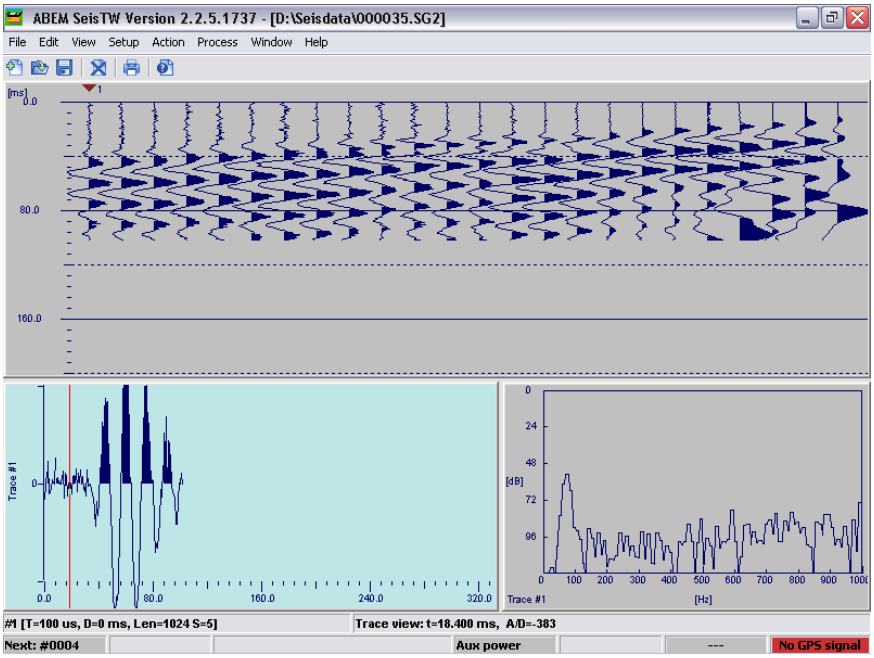


Figure 21 The red timeline

Note!	Keeping the key pressed will accelerate the movement of the timeline

A reference time marker can be positioned at the location of the time line. If the time line is moved when the reference time marker is active, the status bar will display, in

addition to the normal information, the relative time and the corresponding frequency (i.e. reciprocal time).

- Position a reference time marker (Figure 22)

  – Press <0> to position a reference time marker

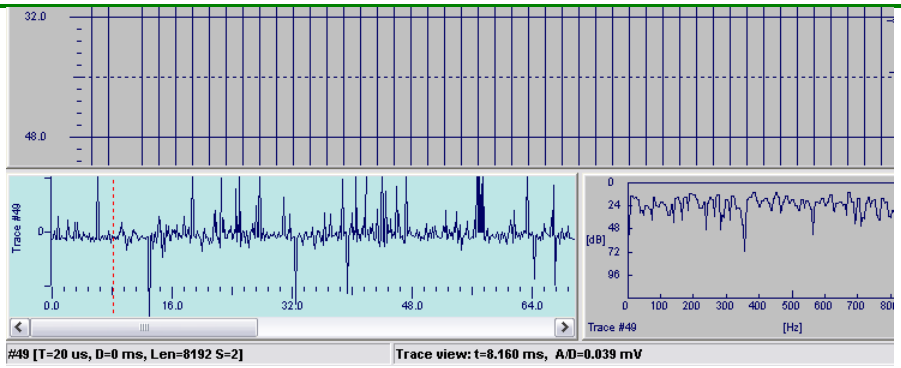


Figure 22 The red dotted reference time marker

- Move the timeline and show relative time (Figure 23)

  – Press <+> to move the timeline to the right

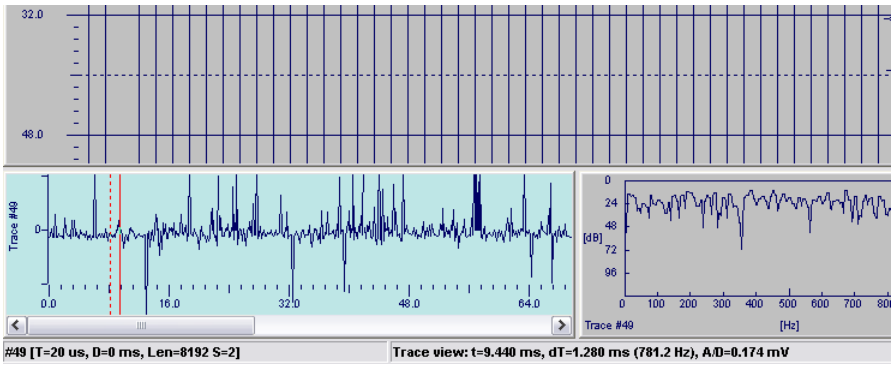


Figure 23 A reference time marker with timeline

- Removing an existing reference time marker

  – Press <-> until the timeline is invisible

  – Press <0> to remove the reference time marker

- Positioning a first break marker (Figure 24)

  – Press <.> to position a first break marker

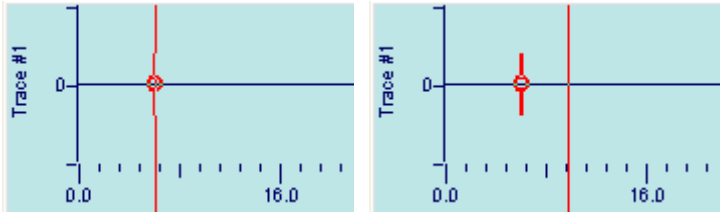


Figure 24 First break marker (timeline moved on the second figure)

- Removing an existing first break marker

  – Press <-> until the timeline is invisible
  – Press <.> to remove the first break marker

4.4.6 Frequency View

The *Frequency View* displays the frequency components of the trace. Here it is possible to check the amplitudes of the frequency components with the frequency line. The frequency and the corresponding amplitude value are displayed on the *Record Status Bar* just below the *Frequency View*.

- Change the trace to view

  – Press <UP> to change to the next trace
  – Press <DOWN> to change to the previous trace

- Moving a frequency line across the view (Figure 25)

  – Press <+> to move the frequency line to the right
  – Press <-> to move the frequency line to the left
  – Press <SHIFT> + <+> to move the frequency line to the right with a large step
  – Press <SHIFT> + <-> to move the frequency line to the left with a large step

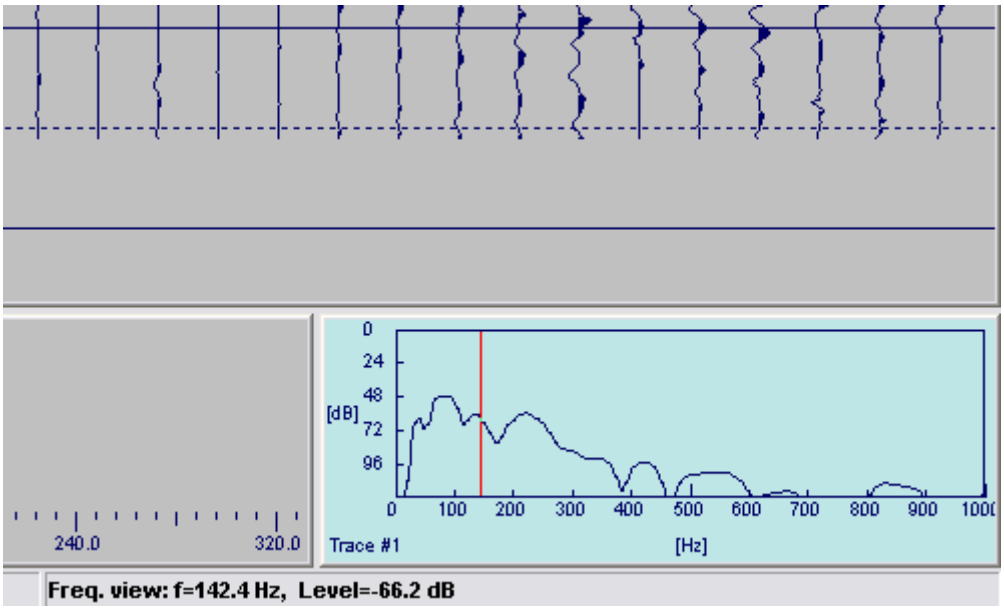


Figure 25 The Frequency View with the frequency line

Note!	Please be aware that the values displayed, mostly are interpolated, as the frequency line represents a frequency calculated from the pixel coordinate, which can be in-between samples.

4.4.7 Record Status Bar

The *Record Status Bar* consists of two fields that displays trace centric information (Figure 26).

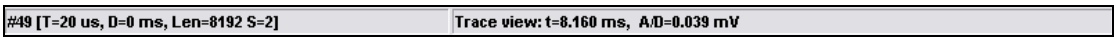


Figure 26 The Record Status Bar

The leftmost field contains information as described in Table 3.

#nn	Trace number
T	Sample interval in microseconds
D	Pre-trig/delay in milliseconds
Len	Length of trace in number of samples
S	Number of stacks

Table 3 Leftmost field information

The rightmost field displays different data depending on which view is highlighted. The following tables describe the three cases.

Note!	There will only be data displayed in the rightmost field if the timeline or frequency line respectively is visible

-	The *Record View*
t	Position of the timeline (ms)
A/D	Measured value at timeline. Unit is available as raw A/D-value, μV, mV, mm/s or cm/s. This is selectable in the view options dialog
-	The *Trace View*
t	Position of the timeline (ms)
A/D	Measured value at timeline. Unit is available as raw A/D-value, μV, mV, mm/s or cm/s. This is selectable in the view options dialog
dT	The relative time (ms), the corresponding frequency within parenthesis. Only displayed when the reference time marker is used
-	The *Frequency View*
f	Frequency (Hz)
Level	Amplitude (db)

Table 4 Rightmost field information

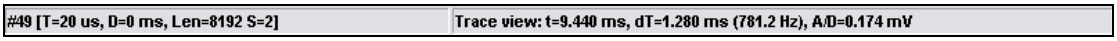


Figure 27 The Record Status Bar with Trace View delta time

4.4.8 Application Status Bar

The *Application Status Bar* displays general status information.

There are seven separate fields on the bar:

Field	Description
The current record number	Is used the next time an acquired record is saved
The active acquisition mode	Standard, Roll-along, or Optimum offset
The current instrument state	For possible states see Table 5 below
Power source status	Internal with voltage  External 
Activated reference channel	The field is blank if no reference channel is activated
Error or warning alert for channels	Each board in the instrument has a one-character place in this field. See the three dashes in Figure 13. The *About* dialog (chapter 4.6.1) shows more information on each board. Possible alerts: - = No error or warning B = Broken channel E = Warning for early trig (see the *Warn for early trig* setting in chapter 4.6.5.2) N= Warning for noisy trig (see the *Warn for noisy trig* setting in chapter 4.6.5.2)
GPS signal indication	Green background with dB value if fully functional Red background with text “No GPS signal” if no signal is detected (usual behavior indoors) Red background with text “No GPS device” if SeisTW cannot get contact with the GPS

No data	There is no data in memory and the instrument is ready to be armed. In this state all acquisition parameters can be changed
<<< ARMED >>>	The instrument is armed and ready for a trigger. In this state no acquisition parameters can be changed
<<< Pending arm >>>	When multiple instruments are connected and synchronized, this state is activated when the user arms one instrument, and it awaits arm confirmation from the other instrument(s)
<<< Triggered >>>	The instrument has triggered and data acquisition is proceeding
Transferring data ...	The data has been acquired and is being transferred to the memory
Data in memory	There is data in the memory; the instrument is ready to be armed. Some, but not all, acquisition parameters can be changed
<<<SAVING>>>	Data is being saved. When the save operation has finished the memory will be cleared, the record number incremented, and the instrument ready to be armed
<<< Testing >>>	The geophone test is active
Geophone test data	The memory contains geophone test data. Press <SAVE> to save the data, or <ESC> to reject
Accept or reject?	Waiting for the user to accept or reject the acquired data for stack in preview mode. Press <ENT> to accept, <ESC> to reject
WARNING	A minor error occurred, or an informational message has to be displayed. Details will be displayed in a separate message
ERROR	A fatal or major error occurred. Detailed information is displayed in a separate error message

Table 5 Instrument states

4.5 Menus

SeisTW has a normal Windows main menu. Since this is easier to use with external mouse and keyboard than with the built-in keyboard there are also two complementing menu choices added, the *Quick Menu* and the *Context Menu*. These duplicates selected items from the *Main Menu*.

There is also a separate pop-up menu, *Clear Traces*, that is used for clearing recorded data when needed.

4.5.1 The Main Menu

The M*ain Menu* is a normal Windows main menu.

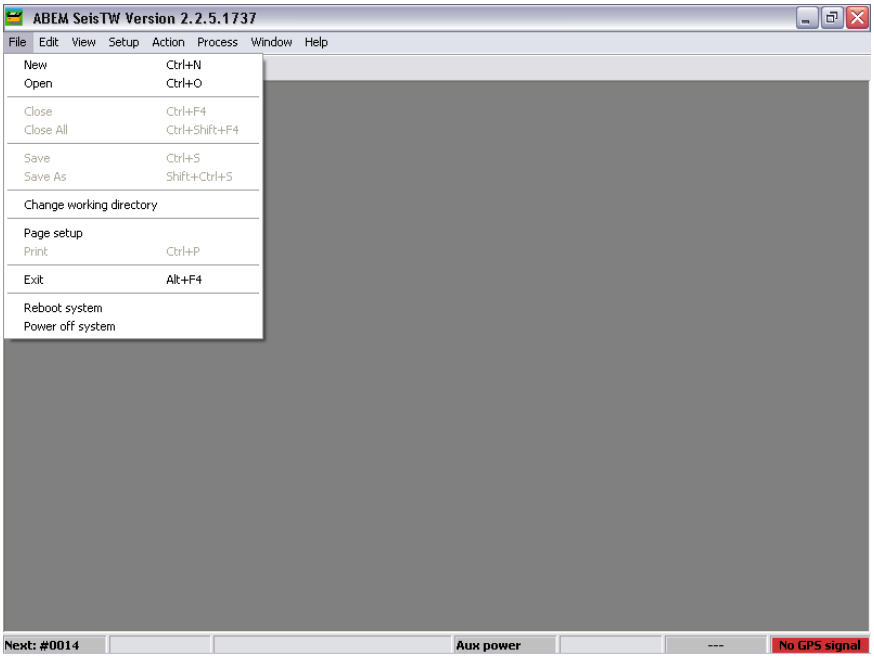
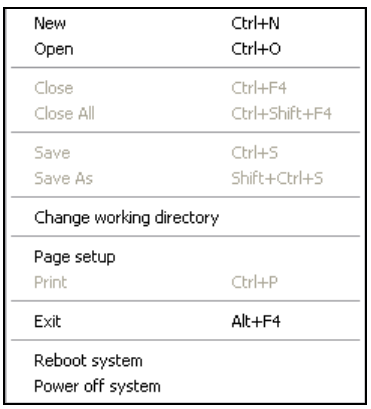
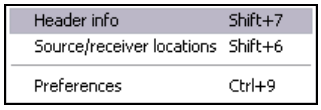
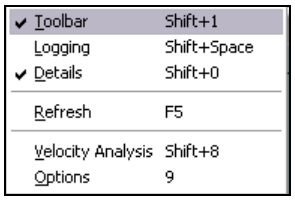
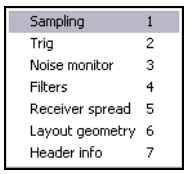
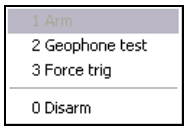
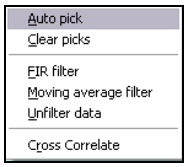


Figure 28 The Main Menu – File menu item opened

Submenu	Submenu items
File 	- New: Create a new record. Opens the *Select Acquisition Mode* dialog (see chapter 4.6.3) - Open: Open a previously saved record. A standard open file dialog is shown - Close/Close All: Close one or all open record(s) - Save: Saves the current record. The current working directory will be used. The filename has the form “DAT_xxxx.sg2” where xxxx is substituted with the next record number - Save As: Same as Save but the user can choose filename and which directory to save in. A standard Save As-file dialog is shown - Change Working Directory: A Browse For Folder-dialog is shown from which the user can choose a new working directory - Page Setup: Opens the standard Page Setup-dialog

	where page orientation, margins etc can be set. - Print: Opens the standard Print-dialog where printer can be chosen. See 12 Appendix D. Printout Example for result examples - Exit: A confirmation dialog is shown and then SeisTW is closed - Reboot system: The instrument is rebooted (restarted) - Power off system: The instrument is turned off
Edit 	- Header info: Displays the *Header info* dialog (chapter 4.6.11) - Source/receiver locations: Displays the *Source/receiver locations* dialog (chapter 4.6.11) - Preferences: Displays the *Preferences* dialog (chapter 4.6.3)
View 	- Toolbar: Hides/Shows the *Toolbar* - Logging: Hides/Shows the *Logging Window* - Details: Hides/Shows *Trace/Frequency* - Refresh: Refreshes the SeisTW window - Velocity analysis: Displays the *Velocity Analysis* dialog (4.6.14) - Options: Displays the *View Options* dialog (4.6.13)
Setup 	- Sampling: Displays the *Acquisition Setup* dialog (4.6.5.1) - Trig: Displays the *Trig Setup* dialog (4.6.5.2) - Noise Monitor: Displays the *Noise Monitor* dialog (4.6.5.3) - Filters: Displays the *Acquisition Filter Setup* dialog (4.6.5.4) - Receiver spread: Displays the *Receiver Spread* dialog (4.6.6) - Layout geometry: Displays the *Layout Geometry* dialog (4.6.9) - Header info: Displays the *Header Info* dialog (4.6.11)
Action 	- Arm: Arms the instrument - Geophone test: Starts a geophone test (4.6.7) - Force trig: Forces a trigger - Disarm: Disarms the instrument
Process 	- Auto pick: Performs an automatic first break pick (5.1) - Clear picks: Clears all first break picks (5.1) - FIR filter: Displays the *FIR Filter* dialog (5.3) - Moving average filter: Displays the *Moving average* dialog (5.5) - Unfilter data: Reloads the original unfiltered data - Cross Correlate: Displays the *Cross Correlate* dialog (5.4)
Window	Standard Windows Window submenu

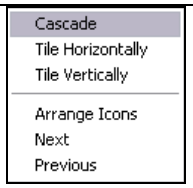
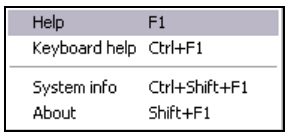
	
Help 	- Help: Displays the help file - Keyboard help: Displays a specific part of the help file - System info: Displays the *System Information* dialog (4.6.2) - About: Displays the *About* dialog (4.6.1)

Table 6 Main Menu items

4.5.2 The Quick Menu

Duplicates most of the menu items from the *File* submenu of the *Main Menu* (Figure 29). See chapter 4.5.1 for specifics on each menu sub item.

- Opening the *Quick Menu*

  – Press <CTR> + <SPACE> to open the *Quick Menu*

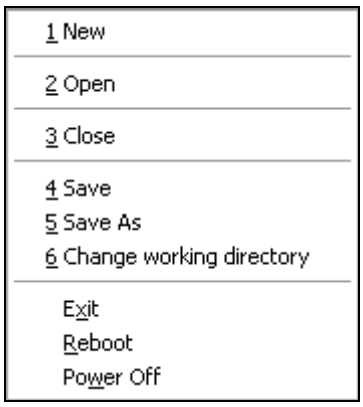


Figure 29 The Quick Menu

4.5.3 The Context Menu

The *Context Menu* exists in two similar versions, a compact and a data version. The compact version is shown when no data exists in the current record (Figure 30). Consequently the data version is shown when data exists (Figure 31).

The compact *Context Menu* duplicates some menu items from three submenus of the *Main Menu* (*Process*, *View* and *Actions*) and also from the *Clear Traces* pop-up menu. See chapter 4.5.1 and 4.5.4 for specifics on each menu sub item.

The data *Context Menu* on the other hand duplicates the entire *Process* submenu as well as some menu items from the *View* submenu and also the *Clear Traces* pop-up menu.

Note!	The *Context Menu* will not be shown if no record is created or opened

- Opening the *Context Menu*

  – Press <SPACE> to open the *Context Menu*

  Or

  – Right-click with a mouse

Figure 30 The Compact Context Menu

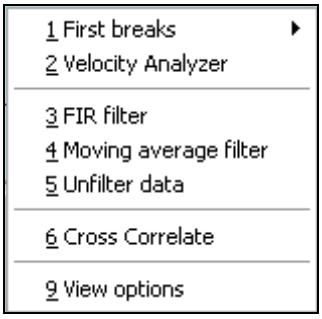


Figure 31 The Data Context Menu

See chapter 5.1 for more on the *First breaks* submenu functions.

4.5.4 The Clear Traces Menu

Used to clear one or more traces of recorded data. In contrast to the *Delete last shot* command these clear traces commands will clear all stackings, if any.

Note!	The menu items of the *Clear Traces Menu* are not available from the *Main Menu.*
Note!	The *Clear Traces Menu* will only be shown when data has been recorded

- Opening the *Clear Traces Menu*

  – Press <ESC> to open the *Clear Traces Menu*

  Or

  – Via the *Clear Traces* submenu of the compact *Context Menu*

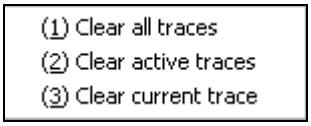


Figure 32 The Clear Traces Menu

4.6 Dialogs

4.6.1 The About Dialog

The *About* dialog displays information about the serial number, software versions, number of boards, number of measurement channels, the health of the boards etc (Figure 33).

- Opening the *About* dialog

  – Press <SHIFT> + <HLP> to open the *About* dialog

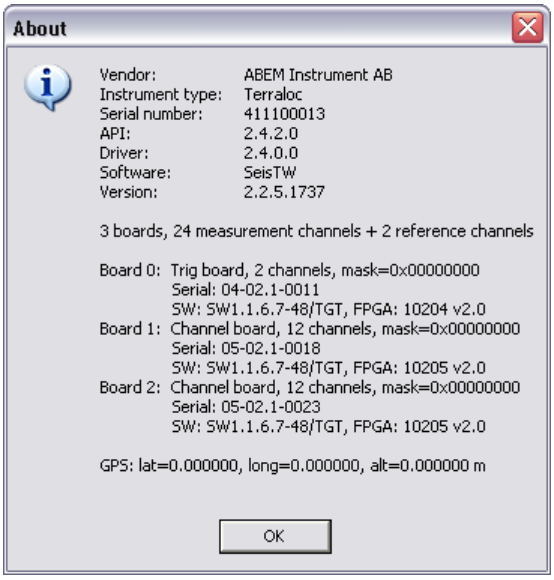


Figure 33 The About Dialog

4.6.2 The System Information Dialog

Displays information about the GPS system status (Figure 34). This dialog can only be accessed from the *Help* submenu of the *Main Menu*.

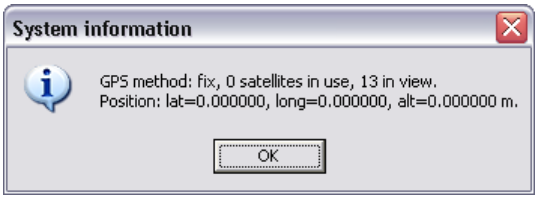


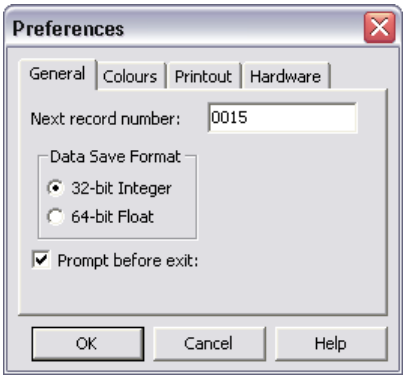
Figure 34 The System Information Dialog

4.6.3 The Preferences Dialog

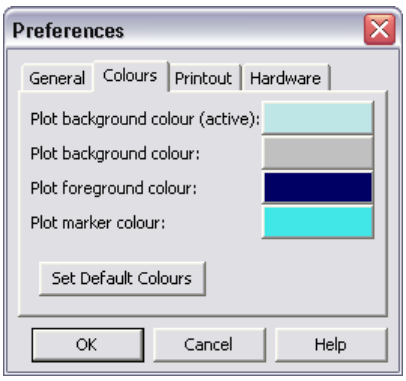
Various general settings can be accessed from this dialog. The settings are divided into four areas, each with its own tab on the dialog.

- Opening the *Preferences* dialog

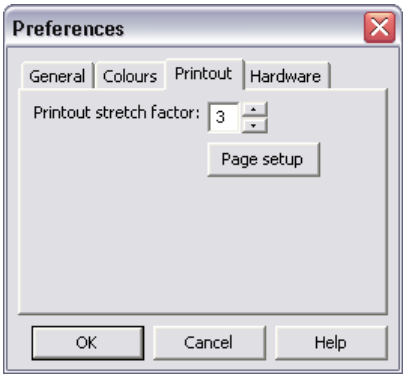
  – Press <CTR> + <9> to open the *Preferences* dialog



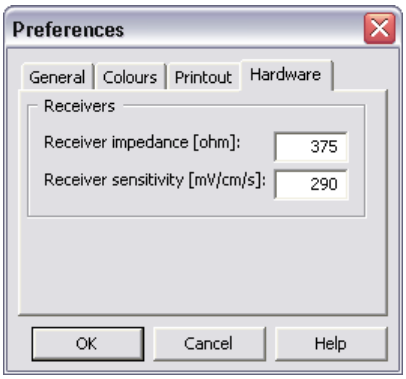
- The next record number is normally incremented automatically but the next number to use can be set here
- The format of the saved recorded data can be set
- By default SeisTW prompts for an exit confirmation but this can be turned off



- Various colors can be set here. The four colored areas are buttons that, when pressed, will show a standard Windows color select dialog.



- The stretching along the timeline can be set here. Values between 1 and 8 are allowed. A higher value result in increased stretch. See 12 Appendix D. Printout Example for result examples



- The impedance and resistivity of the receivers are set here

4.6.4 The Select Acquisition Mode Dialog

The *Select Acquisition Mode* dialog is used to change the acquisition mode and to change the number of traces to be used (Figure 35).

- Opening the *Select Acquisition Mode* dialog
  - Press <CTR> + <SPACE> to show the *Quick Menu*
  - Press <1> to execute the *New* menu item, which will open the *Select Acquisition Mode* dialog

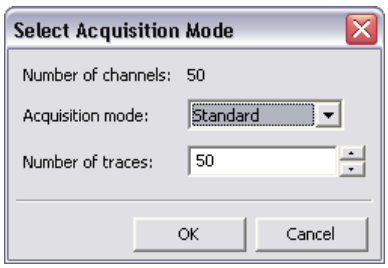


Figure 35 The Select Acquisition Mode Dialog

The different acquisition modes:

Standard	-	All acquisition is performed according to the current settings. The only automatic actions are clearing the memory and updating the record after a save & update operation. The number of traces to use can be changed in this mode only from this dialog
Roll-along	-	When first pressing <ARM>, a new record is created containing the number of traces defined by the Roll-along start/end parameters in the Layout Geometry Dialog. Pressing <SAVE> will cause the record to be saved and the roll-along parameters to be updated according to the Roll-along step size as defined in the Layout Geometry Dialog. How the Roll-along parameters are updated is determined by the Roll-along reverse direction check box
Optimum offset	-	When a record is created it will initially only have the first trace's stack enabled. Besides, only the currently active trace and traces containing data will be visible. When the data for the currently active trace has been acquired, the user can press <SAVE>, which will advance the active trace one trace. Pressing <SAVE> when the last trace is active will save and update the record. It is still possible for the user to modify acquisition parameters, including receiver spread parameters, but be careful. Modifying receiver spread parameters, may lead to acquiring data on a trace that already contains data, but should not be updated

Table 7 Acquisition Modes

4.6.5 The Acquisition Setup Dialog

The *Acquisition Setup* dialog is a container for four different categories of settings for data acquisition: sampling, trig, noise and filters (Figure 36). Each category has its own tab on the dialog and they will be described in separate sub-chapters below. It is also possible to access them all without closing the dialog in-between.

- Switching between setting categories when the dialog is displayed

  – Press <CTR> + <TAB> to switch to the next category (tab)

  Or

  – Press <SHIFT> + <CTR> + <TAB> to switch to the previous category (tab)

SeisTW will remember the latest used combined acquisition settings between sessions. It is also possible to save the settings to disk and later reload them. The settings are stored in acquisition settings files (*.acq), which are text files with an ini-file format.

- Saving acquisition settings to disk

  – Press <TAB> until the *Save* button is selected

  – Press <ENTER> (or <SPACE>) to open a save as dialog

  – Name the file by pressing <NUMBERS>

  – Press <ENTER> to save the file

- Reloading acquisition settings from disk

  – Press <TAB> until the *Load* button is selected

  – Press <ENTER> (or <SPACE>) to open a select file dialog

  – Press <SHIFT> + <TAB> to move the focus to the file list

  – Press <ARROWS> to select the wanted file

  – Press <ENTER> to reload the file

- Restore default acquisition settings

  – Press <TAB> until the *Default* button is selected

  – Press <SPACE>

4.6.5.1 The Sampling Settings Category

These settings control how SeisTW will sample data.

- Opening the *Sampling Settings* (*Acquisition Setup* dialog with the Setup tab selected)

  – Press <1>

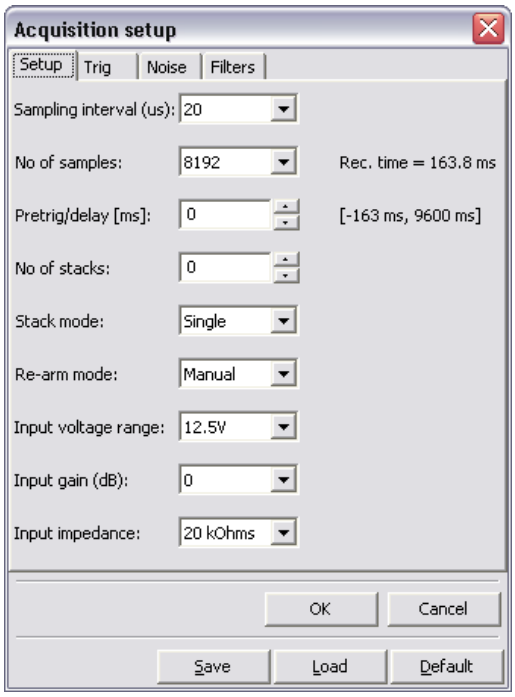


Figure 36 The Acquisition Setup Dialog; Setup tab selected

The resultant record length will vary from short (5.1 ms) to long (80 minutes) depending on your choice of sampling interval and number of samples to be recorded.

Record length = 'Sampling interval' x 'Number of samples'

If a long sampling interval is combined with a low number of samples, the resulting record file will be small (takes up less disk space), but will contain less information and your interpretation possibilities will be reduced. Conversely, a short sampling interval with a high number of samples will give you good information for interpretation, but file size will be larger. Your choice will always be a compromise

Usually the sampling interval is determined by other factors than the record length. Thus, changing the number of samples to record usually varies the record length. However, if the number of samples available cannot give a suitable record length you may have to change the sampling interval

Stacking is a function to enhance the quality of the recorded data. Samples from more than one shot are added to each other giving a suppression of noise in comparison to the relevant data.

Setting	Description
Sampling interval	- Available sample intervals are: 20, 40, 100, 200, 400, 1000, 2000, 4000 and 10000 microseconds
No of samples	- Number of samples to acquire. Available choices are: 256, 512, 1024, 2048, 4096, 8192, 16384, 32768, 65536, 131072, 262144, 480000
Pretrig/delay (ms)	- Selects the pre-trig or delay for the trig event. Pre-trig is set by entering a negative time, and will save the corresponding amount of data before the trig event. Delay is set by entering a

positive time, and will delay data acquisition after the trig corresponding to the delay. The pre-trig/delay is measured in milliseconds. The pre-trig can be set from 1 ms to the record length. The delay can be set to the following ranges:

Sample interval (ms)	Delay range (s)
20	0 - 9.6
40	0 - 19.2
100	0 - 48.0
200	0 - 96.0
400	0 - 192.0
1000	0 - 480.0
2000	0 - 960.0
4000	0 - 1920.0
10000	0 - 4800.0

No of stacks

- If this number is greater than zero, the record will be saved automatically when this number of stacks has been acquired. If you type 0 (zero), stacking will continue until you press <SAVE>. Even if you type a number higher than 0 (zero) you may always interrupt stacking by pressing the <SAVE> key. When the record has been saved, the next record will be initialized

Stack mode

- The stack mode determines how the acquired data is added to the stack and how it is displayed.
  The following stacking modes are available:

Name	Description
Fast	Adds the acquired data to the stack as soon as the data is available. Does not display the data. The instrument is automatically armed for the next shot. This mode gives the highest rate for data collection as no screen update takes place
Auto	The same as the Fast stack, but the stacked data is displayed. The instrument is automatically armed for the next shot
Preview	Displays the acquired data and prompts the user to accept or reject the data. When the data is accepted, it is added to the stack, and the stacked data is displayed. Press <ENT> to accept or <ESC> to reject the acquired data. The instrument is automatically armed for the next shot. If a new shot is received before the <ENT> key is pressed the previous shot is lost. The last shot added to the stack cannot be removed by the “delete last shot” feature
Single	Same as Auto stack, but the instrument has to be manually armed again for the next shot

Re-arm mode	-	If it is set to Auto, the instrument is automatically armed after a record has been saved. This is useful in, for example, marine surveys. If set to Manual the user has to arm the instrument by pressing <ARM>, or some external arm source has to set the arm input to its armed state.
Input voltage range	-	Available choices are: 500 mV, 5.0 V and 12.5 V
Input gain (dB)	-	This setting complements the Input voltage range setting Available choices are: 0, 12, 24, 36, 48
		Note! Setting the input gain to 0 dB makes it possible to measure frequencies down to 0 Hz whereas higher settings gives measurement down to 1 Hz
Input impedance	-	Set up for different types of sensors. Examples are 3000 Ohm for ABEM sensors and High for hydrophones Available choices are: 3000 Ohm, 20 kOhm, High

Table 8 Sampling settings

4.6.5.2 The Trig Settings Category

These settings control when SeisTW will sample data i.e. how sampling will be triggered (Figure 37).

- Opening the *Trig Setup* dialog (*Acquisition Setup* dialog with the Trig tab selected)

  – Press <2>

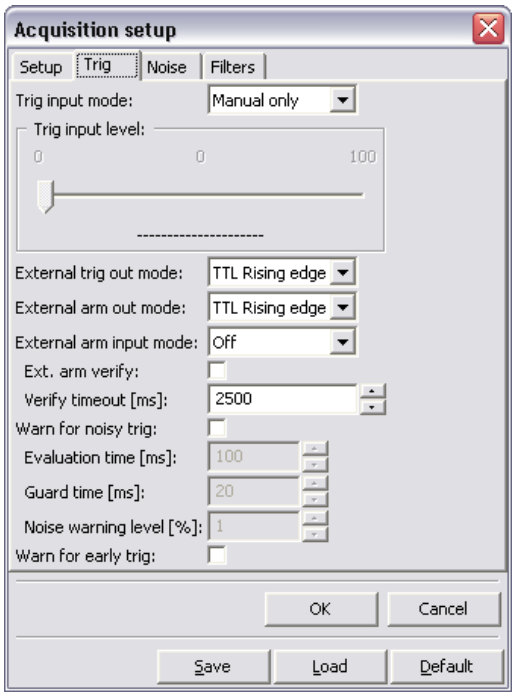


Figure 37 The Acquisition Setup Dialog; Trig tab selected

<table>
<tr><th>Setting</th><th>Description</th></tr>
<tr><td>Trig input mode</td><td>- Selects trig input source, and its mode
The following modes are available:

Name — Description
Analog — When using the trigger input connector, the instrument is triggered when the signal exceeds the trig input level on the analog trig input. Select Analog when you use a standard trigger geophone or a trigger coil. If you use Analog triggering, you should check and/or set the trig input level.
Make/Break — The instrument is triggered when a trigger circuit connected to the trigger input connector is closed (make) or opened (break). The trigger circuit can for example be a twisted pair of insulated wires inserted in a dynamite charge. The wires are then shorted when the charge explodes (make switch). A break switch can be a single wire, which has been wound a few turns around the charge and the explosion cuts the wire (break switch). The instrument detects the state change from opened to closed (make), or from closed to opened (break), depending on the state at the time of arm. Set Trig Input Level to a low value to avoid inadvertent triggering by spurious signals.
TTL Rising Edge — The instrument is triggered when the TTL signal on the digital trig input goes from low to high
TTL Falling Edge — The instrument is triggered when the TTL signal on the digital trig input goes from high to low
Channel — The instrument is triggered when the signal on any channel input, including the reference channels, exceeds the trig input level. If you use Channel triggering, you should check and/or set the trig input level.
Manual only — The instrument will only trigger manually from the keyboard (internal or external)</td></tr>
<tr><td>Trig input level</td><td>- The trig input level can be set from 0 to 100%.
Increasing the trigger input level increases the sensitivity, which means that a lower signal level is needed to trig the Terraloc Pro. Decreasing the trigger input level on the other hand decreases the sensitivity, which means that a higher signal level is needed to trig the Terraloc Pro. Sensitivity level needs to be high enough to ensure triggering by the trigger signal, but not so high that spurious signals will trigger in advance of the actual shot impulse. For example, when a geophone is used as the source of the trigger signal, a time</td></tr>
</table>

delay will always be present between the shot instant and the triggering time. There are two main causes for this:

1. The propagation delay from the shot point to the geophone
2. The rise time of the geophone output signal to the triggering level

Figure 38 illustrates the relationship between trigger sensitivity and the rise time of the receiver output signal to the triggering level.

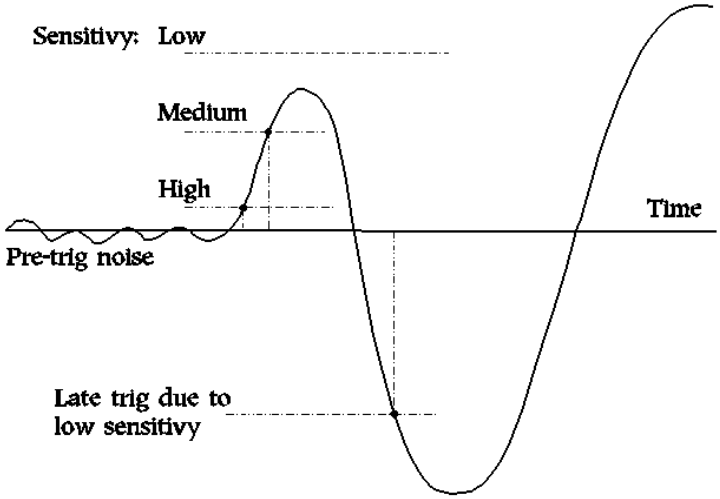


Figure 38 Trig signal from a geophone and the trig event

To reduce the propagation delay the only way is to move the geophone closer to the shot point. This cannot always be done due to physical limitations in which case you will have to accept the delay.
The rise effect is another matter, because it is influenced by a number of conflicting requirements. If the trigger sensitivity is increased, the result is of course an earlier trig event, but increasing the sensitivity also means that the risk of triggering the system by a noise signal increases. If the sensitivity is too low, noise triggering will not occur, but instead a considerable and poorly defined delay is introduced. This can seriously degrade the performance of the stacking of signals, since any signal with a period time comparable to, or less than this trig event uncertainty, will be attenuated. So in conclusion, you will have to find a suitable compromise between high sensitivity to false triggering and large timing errors.

Warn for noisy trig	- The meaning is to warn when there is a risk that sampling was triggered on noise instead of signal level. A possible warning is shown in the status bar (see chapter 4.4.8). This setting, together with its three sub settings (below), decides how the evaluation is done. If the signal level is higher than the given level in connection with the trigger point then the warning is raised. Figure 39 illustrates the meaning of the involved settings.

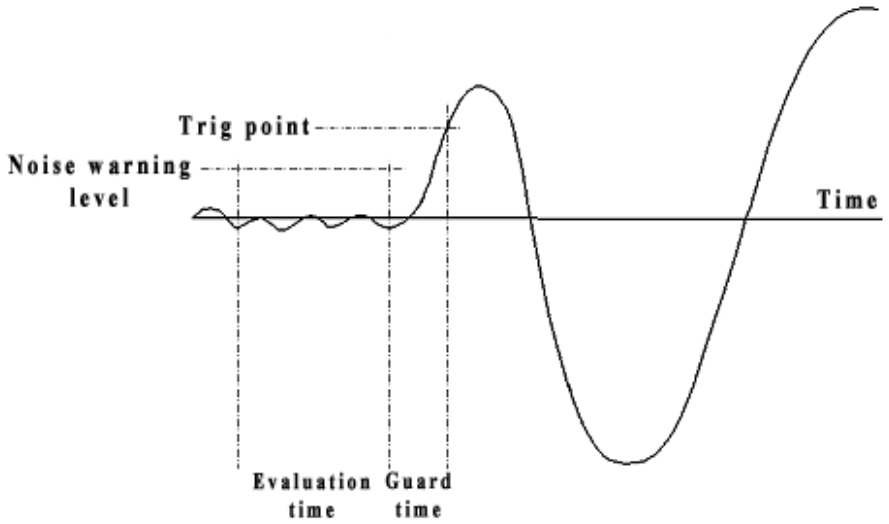


Figure 39 Trig signal from a geophone and the trig event

Evaluation time [ms]	-	The time window during which the signal level is checked against the *Noise warning level*. See Figure 39 above
Guard time [ms]	-	A time window where the signal level is not checked. This is to avoid false warnings from the time just before the trig point. See Figure 39 above
Noise warning level [%]	-	The threshold level for the noise warning. See Figure 39 above
Warn for early trig	-	The meaning is to warn when there is a risk that sampling was triggered before a stable measurement was possible. A possible warning is shown in the status bar (see chapter 4.4.8).

Table 9 Trig settings

External Arm Input

External arm is used when interconnecting two or more Terraloc Pros using the TTL Arm/Trig connector (Figure 69 chapter 10.3). There is no limit for how many Terraloc Pros may be connected in this way. When external arm input is on the Terraloc Pro monitors the input continuously and if a correct signal is received the Terraloc Pro will arm.

Note!	If you have several instruments or devices connected in a "daisy chain", you must ensure that both Arm Input mode and Arm Out mode are properly defined on each instrument (i.e. they must all be set to either TTL rising edge or TTL falling edge)

External Arm/Trig Output

Use this to inform other electronic devices (seismographs, vibrators, computers, etc) that the Terraloc Pro has triggered. The signal is in TTL standard and uses the TTL Arm/Trig connector (Figure 69 chapter 10.3)

Setting	Description
External trig out mode	- The following modes are available: **Name** — **Description** Off — The Trig-out is off TTL Rising Edge — The instrument will make the trig-out signal go from low to high when the instrument gets armed TTL Falling Edge — The instrument will make the trig-out signal go from high to low when the instrument gets armed
External arm out mode	- The following modes are available: **Name** — **Description** Off — The Arm-out is off TTL Rising Edge — The instrument will make the arm-out signal go from low to high when the instrument gets armed TTL Falling Edge — The instrument will make the arm-out signal go from high to low when the instrument gets armed
External arm input mode	- The following modes are available: **Name** — **Description** Off — The TTL Arm/Trig input is not monitored TTL Rising Edge — The instrument is armed when the TTL signal on the TTL Arm/Trig input goes from low to high TTL Falling Edge — The instrument is armed when the TTL signal on the TTL Arm/Trig input goes from high to low
Ext. arm verify	- When several instruments are interconnected, the external arm inputs and outputs can be connected in such a way that when one instrument is armed it in turn will arm the next instrument. If this choice is checked when the user presses <ARM> on one instrument, it will wait until it receives an external arm from the last instrument in the chain before actually accepting the arm event. If no external arm is received within the timeout set, the instrument will disarm and the disarm event will propagate to all the other instruments
Verify timeout [ms]	- The time to wait for an external arm before disarming and showing an error message

Table 10 External Arm/Trig settings

4.6.5.3 The Noise Monitor Settings Category

The *Noise Monitor Setup* dialog (Figure 40) has settings that control the *Noise Monitor* dialog (chapter 4.6.6).

- Opening the *Noise Monitor Setup* dialog (*Acquisition Setup* dialog with the Noise tab selected)

  – Press <3>

Figure 40 The Acquisition Setup Dialog; Noise tab selected

Setting	Description
Noise monitor status	- When the noise monitor is On, it will be displayed when the instrument is armed. Available choices are: On, Off
Attenuation [dB]	- Attenuation in decibels of the displayed signal. The maximum displayed signal level is always 120 dB, but the lowest signal level displayed can be set by changing the Attenuation
Threshold level [dB]	- Sets a threshold level in decibels. Size depends on amplitude scale of the noise monitor. When the monitored signal exceeds this threshold level, a warning is displayed in the noise monitor window
Show noise	- Press this button to directly display the noise monitor. Press <ESC> to close it

Table 11 Noise Monitor settings

4.6.5.4 The Filters Settings Category

These settings control how SeisTW filter data to be sampled (Figure 41).

- Opening the *Filters Setup* (*Acquisition Setup* dialog with the Filters tab selected)

  – Press <4>

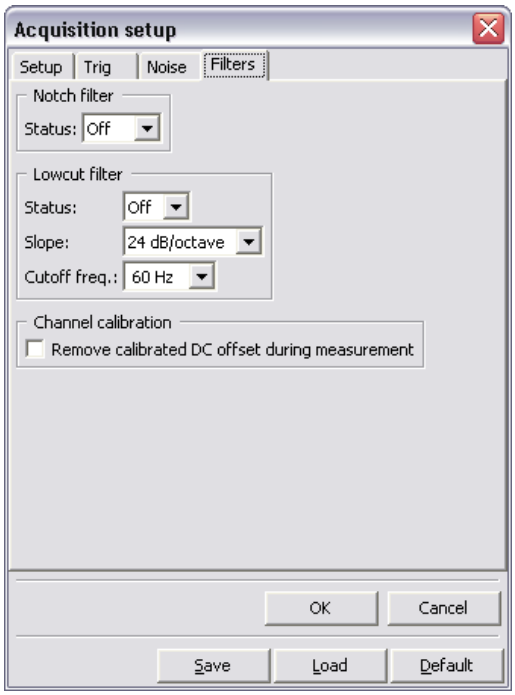


Figure 41 The Acquisition Setup Dialog; Filters tab selected

Signals usually contain noise from sources such as wind and traffic. This noise often has low frequency. Analog filter removes these frequencies from the signals. However, the filter may also deteriorate original signals. The higher the cut-off frequency and filter damping, the worse possible distortions become. Using an analog filter is always a compromise.

If the noise level is high, record it. Use the frequency view to analyze it, and to see the actual noise frequency. Thereafter select and use an appropriate analog filter.

If the noise level is not high, do not use the analog filters.

Analog filters affect all channels.

Note!	Note that you will not be able to recover any incoming signals that are filtered out. Use analog filters only to remove low frequency ground roll. Generally be cautious about using these filters, as there is always a risk that they may eliminate valuable signal information

Setting	Description
Notch filter	- Turns the notch filter on or off. The notch filter is calibrated at factory for either 50 or 60 Hz. Use this when working in vicinity of

	power lines otherwise leave it off. A spectrum analysis of a noise recording may often show if power line noise is present
Lowcut filter Status	- Turns the analog low-cut filter on or off
Lowcut filter Slope	- Select the slope of the filter. Available choices are 12 dB/octave and 24 dB/octave
Lowcut filter Cutoff freq.	- Selects the low cutoff (3 dB rejection) frequency in Hz. The possible frequency choice depends on the selected slope. You have 16 different cut-off frequencies for each filter slope to choose from, see the table below. When choosing filter slope, remember that generally 24 dB/octave filters distort more than 12 dB/octave, but will also damp noise more effectively. Use as low a cut off frequency as possible generally twice the maximum noise frequency. A good rule is to start with the 12-dB/octave filter. If the recorded signal is acceptable then keep the filter, otherwise try again with the 24-dB/octave filter.

12 dB/octave	**24 dB/octave**
12	15
24	30
36	45
48	60
60	75
72	90
84	105
96	120
108	135
120	150
132	165
144	180
156	195
168	210
180	225
192	240

Table 12 Filter settings

4.6.6 The Noise Monitor Dialog

There is a real-time noise monitor integrated in the system. It is displayed in the *Noise Monitor* dialog (Figure 42). The *Noise Monitor* can be used to just inspect the noise level, or monitor the noise so that the operator is able to fire the shot at the right moment.

- Opening the *Noise Monitor* dialog

  – The *Noise Monitor* is opened either directly from *Noise Monitor Setup* dialog with the *Show Noise* button or when the *Noise Monitor Status* is turned on and

the instrument is armed

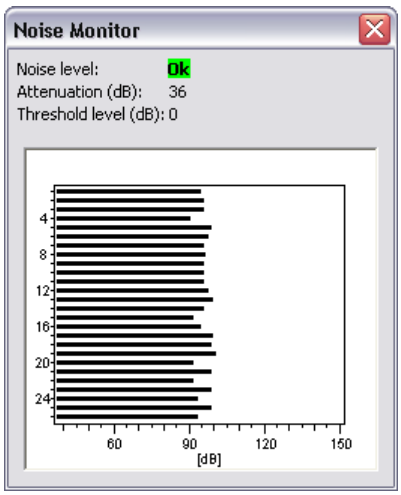


Figure 42 The Noise Monitor Dialog

- Adjusting the attenuation (Figure 43)

  – Press <SHIFT> + <+> to increase the attenuation in 6 dB step

  – Press <SHIFT> + <-> to decrease the attenuation in 6 dB step

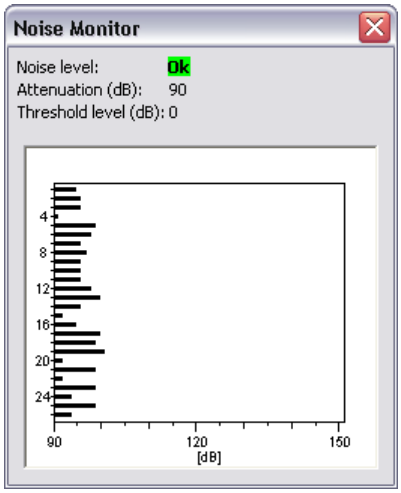


Figure 43 Increased attenuation value

- Adjusting the threshold (Figure 44)

  – Press <+> to increase the threshold in 1 dB step

  – Press <-> to decrease the threshold in 1 dB step

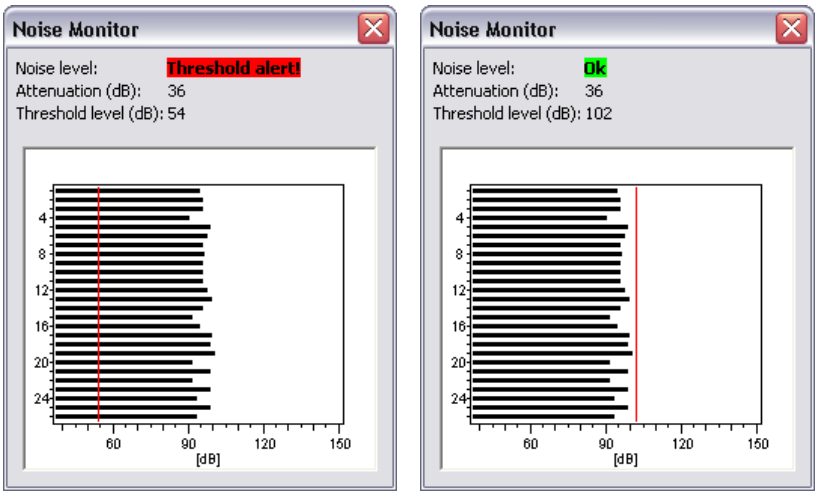


Figure 44 Threshold adjustments

- Activate geophone test relays (Figure 44)
  - Press <SPACE> to activate test relays. It is not possible to do this when the instrument is armed

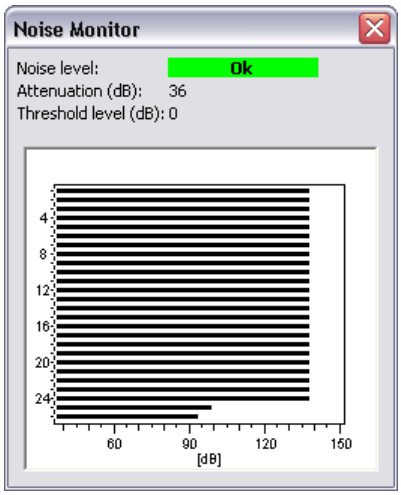


Figure 45 After activation of test relays

4.6.7 The Geophone Test Result Dialog

This geophone test is more extensive than the geophone check available in the *Noise Monitor*. This test records the response from the geophones to an impulse signal. A DC-current is sent to the geophones dislocating the seismic mass of the geophone. When the DC-current is switched off, the mass performs a damped oscillation with its resonance frequency while it comes to rest. Thus, you will get a report on the maximum amplitude of the response, resonance frequency and damping.

The recording of the response starts just before the DC-current is switched off. The response is recorded and SeisTW then analysis the recorded test data and determines the status of each channel.

After the analysis of the data has been performed the result is displayed as a normal record and as a report-log in a *Textfile Viewer* dialog. Furthermore these results are also saved in the current working directory as a record in SG2-format and as a report in text format. The files have file extensions of ".sg2" and ".log" respectively. The filename pattern is: TEST_xxxx-n where xxxx is the current record number and n is a serial number.

- Starting the geophone test, which eventually displays the *Geophone Test Result* dialog

  – Press <SHIFT> + <ARM>

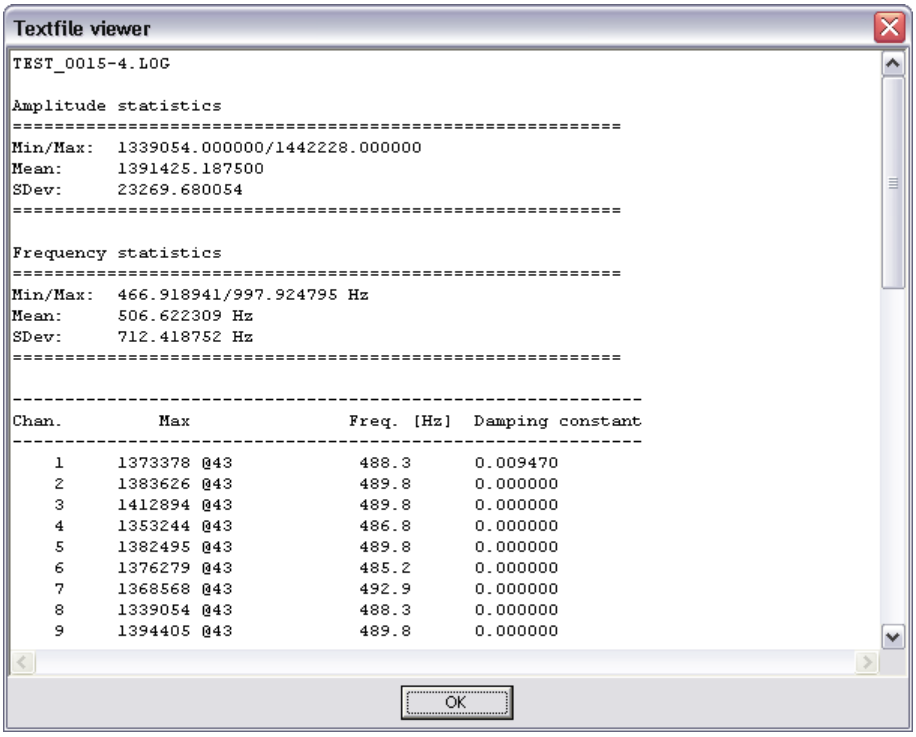


Figure 46 The Geophone Test Result Dialog

4.6.8 The Receiver Spread Dialog

The *Receiver Spread* dialog is used to set up the traces, including input channel mapping and polarity (Figure 47).

- Opening the *Receiver Spread* dialog

  – Press <5>

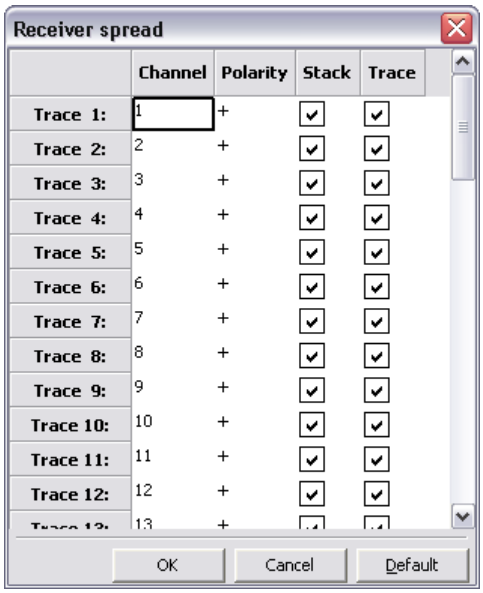


Figure 47 The Receiver Spread Dialog

Note!	Default settings can be reloaded by using the *Default* button

Channel

Specifies the channel mapped to each trace. It is possible to map any channel to any trace, and one channel can be mapped to any number of traces. If the reference channel is enabled, it will be mapped to the trace as specified by the corresponding channel.

- Changing channel mapping
  - Press <ARROWS> to select the wanted trace in the channel column
  - Press <NUMBERS> to change the input channel of the trace

- Map all channels in forward direction (channel 1 to trace 1, 2 to 2 etc)
  - Press <ARROWS> to select any trace in the channel column
  - Press <SHIFT> + <+>

- Map all channels in reverse direction (channel 24 to trace 1, 23 to 2 etc for a 24 channel instrument)
  - Press <ARROWS> to select any trace in the channel column
  - Press <SHIFT> + <->

Polarity

Specifies the polarity of the recorded signal. If the polarity is positive, the signal will be stored as is. If the polarity is negative, the signal will be inverted before it is stored.

- Changing polarity on one trace

– Press <ARROWS> to select the wanted trace in the polarity column
– Press <SPACE> to toggle the polarity

Or

– Press <+> to set a positive polarity

Or

– Press <-> to set a negative polarity

- Changing polarity on all traces

– Press <ARROWS> to select any trace in the polarity column
– Press <SHIFT> + <SPACE> to toggle the polarity on all traces

Or

– Press <SHIFT> + <+> to set all traces to a positive polarity

Or

– Press <SHIFT> + <-> to set all traces to a negative polarity

Stack

Enables or disables stacking for the specified trace. If the stack for a trace is disabled (non-checked), data cannot be added (or subtracted) from that stack.

- Changing stack state for one trace

– Press <ARROWS> to select the wanted trace in the stack column
– Press <SPACE> to toggle the value

Or

– Press <1> to set a checked value

Or

– Press <0> to set a non-checked value

- Changing stack state for all traces

– Press <ARROWS> to select any trace in the stack column
– Press <SHIFT> + <SPACE> to toggle the value on all traces

Or

– Press <SHIFT> + <1> to set all traces to a checked value

Or

– Press <SHIFT> + <0> to set all traces to a non-checked value

Trace

Enables or disables viewing of the specified trace.

Note!	All traces will be recorded regardless of the *Trace* value

- Changing trace state for one trace

  – Press <ARROWS> to select the wanted trace in the trace column

  – Press <SPACE> to toggle the value

  Or

  – Press <1> to set a checked value

  Or

  – Press <0> to set a non-checked value

- Changing trace state for all traces

  – Press <ARROWS> to select any trace in the trace column

  – Press <SHIFT> + <SPACE> to toggle the value on all traces

  Or

  – Press <SHIFT> + <1> to set all traces to a checked value

  Or

  – Press <SHIFT> + <0> to set all traces to a non-checked value

4.6.9 The Layout Geometry Dialog

The *Layout Geometry* dialog is divided into five different sections (Figure 48). Each section is described separately below.

- Opening the *Layout Geometry* dialog
  - Press <6>

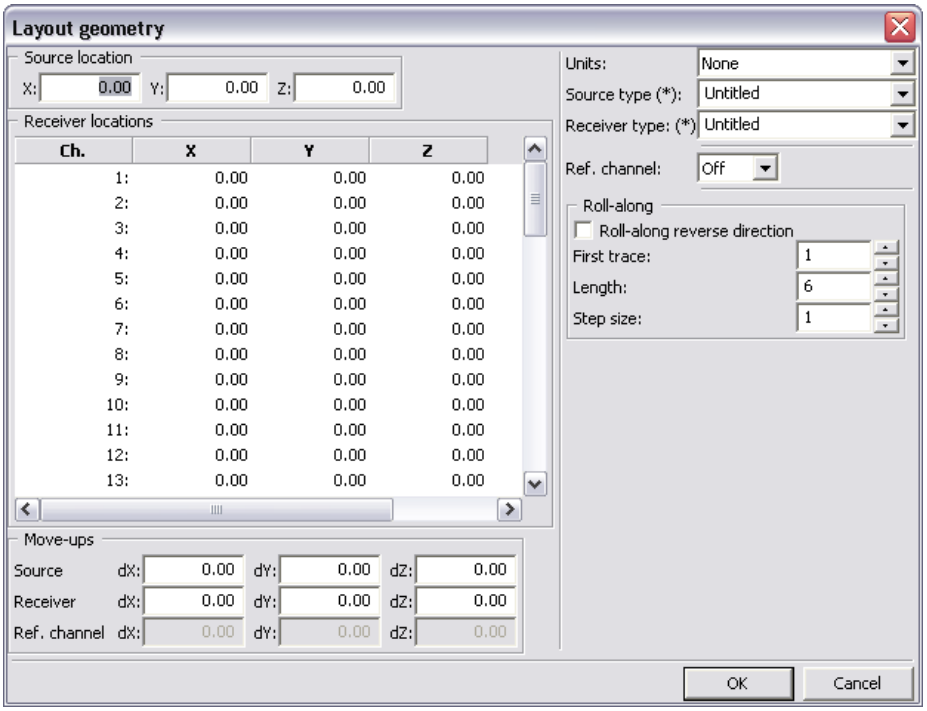


Figure 48 The Layout Geometry Dialog

Source location

X, Y, and Z are coordinates of the source location.

- Changing a value
  - Press <TAB> to select the X, Y or Z value to be changed
  - Press <NUMBERS> and possibly <-> and <.> to construct a valid value
  - Press <TAB> to set the value and move to the next value

Receiver locations

X, Y, and Z are coordinates for the receivers.

- Changing a value

  – Press <ARROWS> to select the X, Y or Z value to be changed

  – Press <NUMBERS> and possibly <-> and <.> to construct a valid value

  – Press <ENT> to set the value and move down to the next value

When the first and second value has been given then the following values can be entered quicker given that the distances are the same.

- Quick completion

  – Press <CTR> + <DOWN>
  This will add the difference between the value in the first row and the second row to the value in the second row and enter this value in the third row.
  This can then be repeated for the following rows.
  Keep holding <CTR> + <DOWN> and all values for the current column will be filled in.
  If the value on the second row is larger than the one in the first row the difference will be added to the value in the second row and entered in the third row etc, for example starting with 0 on the first row and 5 on the second row will produce 10, 15, 20 etc in the following rows.
  If the value on the second row is smaller than the one in the first row the difference will be subtracted from the value in the second row and entered in the third row etc, for example starting with 100 on the first row and 95 on the second row will produce 90, 85, 80 etc in the following rows.

Note!	Both positive and negative values are allowed

- Opening the *Layout Helper* dialog (see chapter 4.6.10) when the marker is located in the receiver locations part of the dialog

  – Press <SPACE>

Move-ups

Describes how the source, receivers and the receiver connected to the reference channel (if any) are updated when a record has been finished.

- Changing a value

  – Press <TAB> to select the dX, dY or dZ value to be changed

  – Press <NUMBERS> and possibly <-> and <.> to construct a valid value

  – Press <TAB> to set the value and move to the next value

Note!	The ref. channel values are only available when the *Ref. channel* drop-down field is set to either *Ch. A* or *Ch. B*

Roll-along

The settings used to control roll-along measurements (see chapter 4.6.4 for more on roll-along). Note that it is assumed that the lowest numbered trace is on the left side and the highest numbered is on the right side.

Setting	Description
Roll-along reverse direction	- If checked, the roll-along segments will be shifted to the left (normally they are shifted to the right)
First trace	- The first (left-most) trace of the current cable layout for the current record
Length	- Number of traces comprising one roll-along segment
Step size	- Number of steps to shift the roll-along after finishing a record

General

These are general settings for all sections of the dialog.

Setting	Description
Units	- Defines the linear units used for all location data. Possible values are: None, Meters, Centimeters, Feet and Inches. If None is specified it will be up to the user to interpret location data
Source type (*)	- An appropriate text string describing the source used to acquire this record. Pre-defined values are: Untitled, Hammer, Weight Drop, Seismic Gun, Explosives, and Vibrator. The asterisk means that the user may enter any text string in this field
Receiver type (*)	- An appropriate text string describing the receivers used to acquire this record. Pre-defined values are: Untitled, Vertical_Geophone, SH_Horizontal_Geophone, SV_Horizontal_Geophone, and Accelerometer The asterisk means that the user may enter any text string in this field
Ref. channel	- Terraloc Pro with 12, 24 and 48 Channels have two extra reference channels. These channels connect thru banana terminals on the connector panel and have their own traces shown on screen Possible values are: Off, Ch. A and Ch. B

4.6.10 The Layout Helper Dialog

The *Layout Helper* dialog (Figure 49) can be used to quickly fill in the receiver locations in the Layout geometry dialog.

- Opening the *Layout Helper* dialog

– Press <SPACE> when the marker is in the Receiver locations section of the *Layout Geometry* dialog

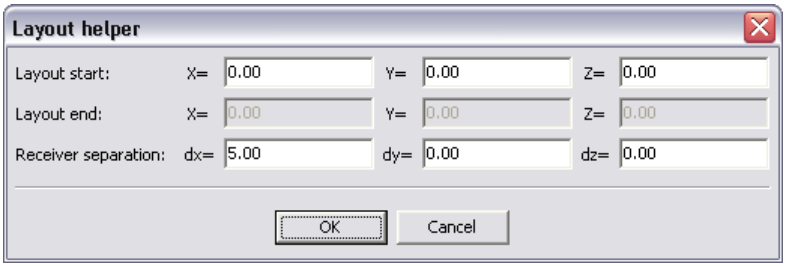


Figure 49 The Layout Helper Dialog

It is possible to enter values in any two of the entries layout start, layout end, and receiver separation. The third entry is calculated automatically.

- Setting an entry to be calculated automatically

  – Press <TAB> to select the entry to be automatically calculated

  – Press <SPACE>

- Accepting the values and exit

  – Press <TAB> to select the OK button

  – Press <SPACE> or <ENT> to exit from the dialog and automatically fill in the receiver locations grid

4.6.11 The Source/Receiver Locations Dialog

This dialog is best used to get a view of source and receiver locations in existing record data. It also displays the locations per trace.

- Opening the *Source/Receiver Locations* dialog

  – Press <SHIFT> + <6> to open the *Source/Receiver Locations* dialog

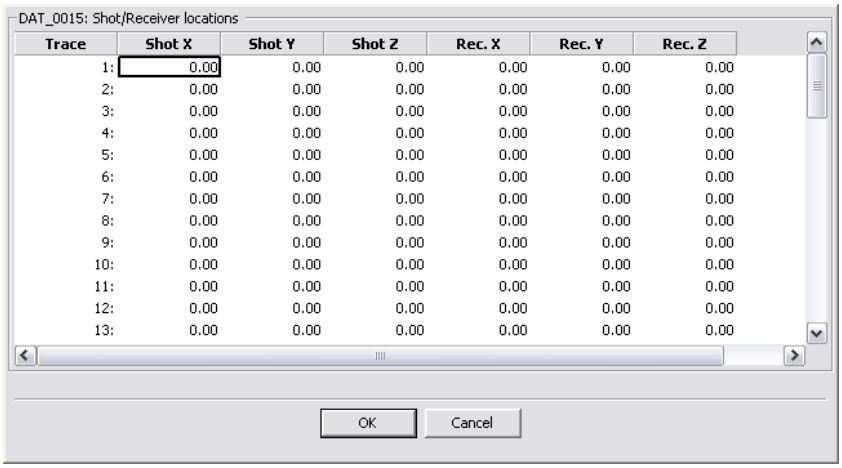


Figure 50 The Source/Receiver Locations Dialog

4.6.12 The Header Info Dialog

The *Header Info* dialog enables input of general header information (Figure 51).

- Opening the *Header Info* dialog

  – Press <7> to open the *Header Info* dialog

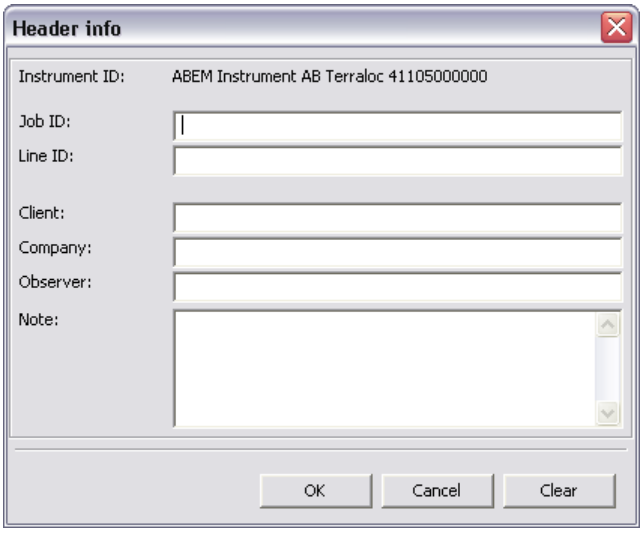


Figure 51 The Header Info Dialog

Note!	Remember that an external USB-keyboard is needed to be able to write letters. Therefore it can be practical to fill in the header info before going out in field

Setting	Description
Job ID	- A text string identifying the job
Line ID	- A text string identifying the seismic line
Client	- A text string naming the client of the job
Company	- A text string naming the company of the client
Observer	- A text string naming the observer(s)
Note	- A free form text string

4.6.13 The View Options Dialog

The *View Options* dialog handles settings for how data is viewed in SeisTW (Figure 52). The dialog is divided into six sections. The *View Mode* setting decides which one of the *Normalize, AGC, Enhanced* and *Hyperbolic* sections that is available for setting up. The *Frequency Analysis* section affects how the *Frequency View* (4.4.6) will present the frequency data.

- Opening the *View Options* dialog

– Press <9>

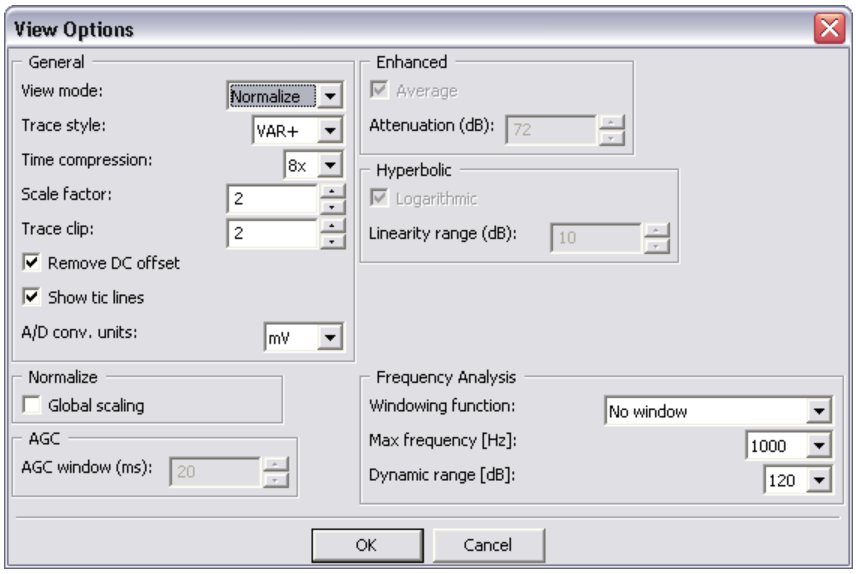


Figure 52 The View Options Dialog

Setting	Description
View mode	- The view mode determines how data is scaled for the display. The following modes are available:

Name	Description
Enhanced	The data is not scaled, but the amplitudes are used directly. It is, however, possible to attenuate the displayed signals using the enhanced attenuation parameter
Normalize	The max value in each trace is used to scale all samples in the trace. See also global scaling
AGC	Uses the average amplitude calculated from a running window (which length is specified by the AGC window parameter). This means that each sample is scaled according to the average signal level in the samples vicinity
Hyperbolic	Applies a hyperbolic scaling to the data. If the logarithmic choice is selected, the function ArcSinH will be used, otherwise the function TanH is used

Trace style - The following styles are available:

Name	Description
VAR+	This is a wiggle trace with the positive side filled-in
VAR-	This is a wiggle trace with the negative side filled-in
Wiggle	The trace is plotted as a wiggle
Dotted	Each sample value is plotted as a dot

Time compression	-	Selects compression in time. This makes more of the record visible. Available values are: 1x, 2x, 4x and 8x
Scale factor	-	A general factor by which every sample is multiplied. Range: 1 – 1000
Trace clip	-	How many traces the plotted curve may overlap before it is clipped. With trace clip = 1, no overlap will occur. If trace clip is 2, a trace may overlap the positive part of the trace on the left, and the negative part of the trace on the right Range: 1 – number of channels
Remove DC offset	-	If enabled, the DC offset is removed before the trace is scaled. It is recommended to keep this enabled
Show tic lines	-	If enabled, major and minor tic lines will be plotted. The time interval between the tic lines is determined by sample interval and time compression

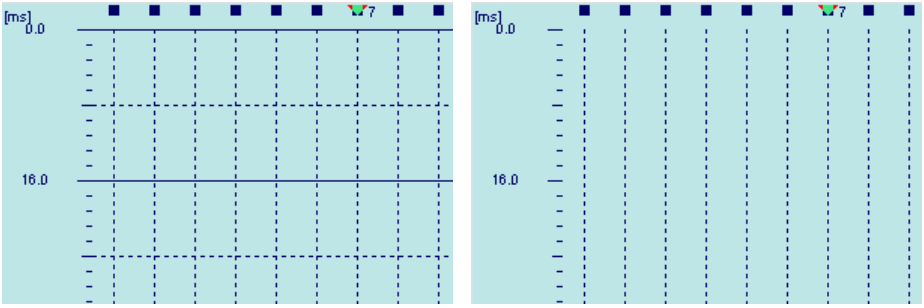


Figure 53 Tic lines On (left) and Off (right)

A/D conv. units	-	Decides the unit type for the A/D-value that is displayed on the *Record Status Bar* (4.4.7). Available values are: None, μV, mV, mm/s, cm/s (None = Raw A/D-value)
Global scaling	-	If enabled, the maximum value in the whole record is used to normalize every sample of all traces. Only available when *View Mode* is set to Normalize
AGC window (ms)	-	The length of the window, in milliseconds, used to calculate the average value to use for scaling of a sample value. The window moves along the trace with each sample that is scaled. Only available when *View Mode* is set to AGC Range 1 – 32000
Average	-	If enabled, the average values on the stack is used for each trace, otherwise the summed stack is used Only available when *View Mode* is set to Enhanced
Attenuation [dB]	-	Used to attenuate the signals. This will bring out weaker signals, while hiding stronger signals. Only available when *View Mode* is set to Enhanced
Logarithmic	-	If enabled, ArcSinH is used as the scaling function otherwise TanH is

		used. Only available when *View Mode* is set to Hyperbolic
Linearity range [dB]	-	This value sets the amplitude level that is within the linear part of the scaling function. Both scaling functions are linear in the beginning (for small amplitudes), while compressing larger amplitudes. Only available when *View Mode* is set to Hyperbolic
Windowing function	-	Selects the function to be used for data windowing. Available values are: No window, Hanning, Hamming, Blackman, Bartlett, Kaiser, 4th order Blackman-Harris, Flat top
Max frequency [Hz]	-	The maximum frequency to display. The displayed spectrum will go from 0 Hz up to the selected maximum frequency. Available values are: 50, 100, 200, 500, 1000, 2000, 5000, 10000, 25000
Dynamic range [dB]	-	The maximum frequency component is used as reference when calculating the spectrum. The displayed spectrum will go from 0 dB up to the selected maximum dB value. Available values are: from 6 dB up to 198 dB in steps of 6 dB

4.6.14 The Velocity Analyzer

The *Velocity Analyzer* consists of a dialog, which is displayed at the top of the screen, and the *Velocity Marker*, a red line that is displayed in the *Record View* (Figure 54). The *Velocity Analyzer* can be used to estimate the apparent seismic velocity in refraction records.

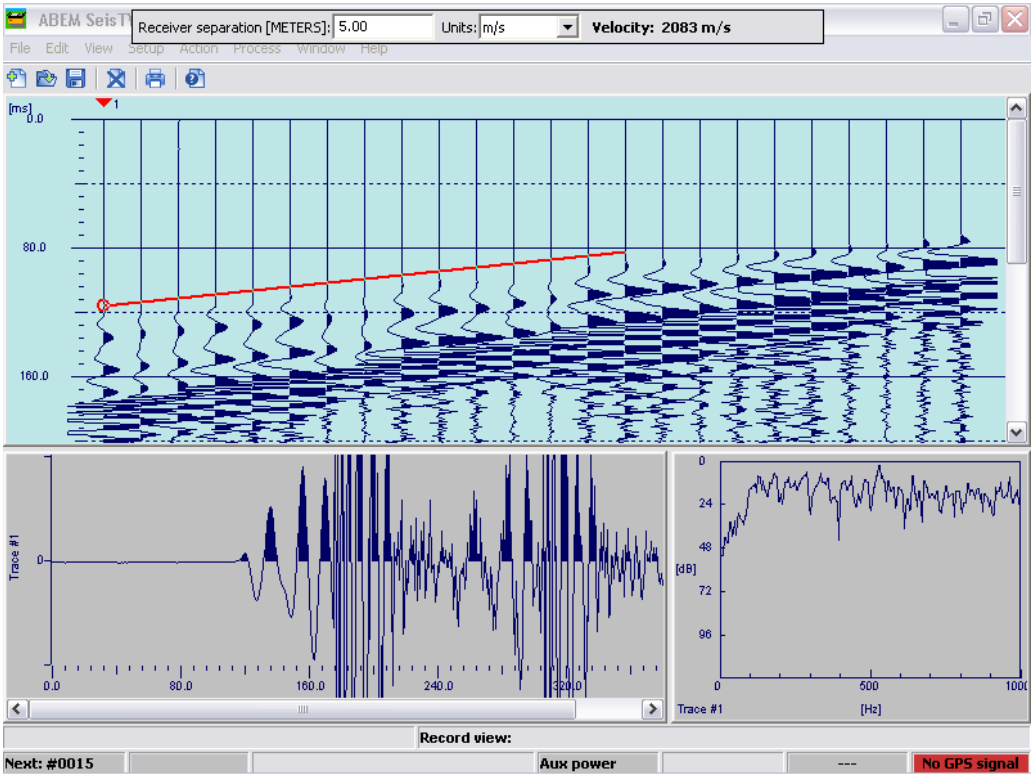


Figure 54 The Velocity Analyzer; Dialog and Velocity Marker

When the *Velocity Analyzer* starts, it checks the receiver locations and calculates the receiver separation. If the receiver separation seems to be erroneous, or the receiver locations are not specified, a valid separation value can be entered in the dialog (Figure 55).

When the *Velocity Marker* is tilted a velocity value is displayed in the dialog. The value is calculated from the slope of the line as a function of receiver separation. This way, you can move and tilt the *Velocity Marker* in such a manner that it correlates with for example first arrivals in a refraction record. Thus it is easy to find out velocities for different layers.

Figure 55 The Velocity Analyzer Dialog

Setting	Description
Receiver separation	- The calculated value can be changed.
Units	- The unit for the velocity value is set here. Available values are: None, m/s, cm/s, ft/s and in/s

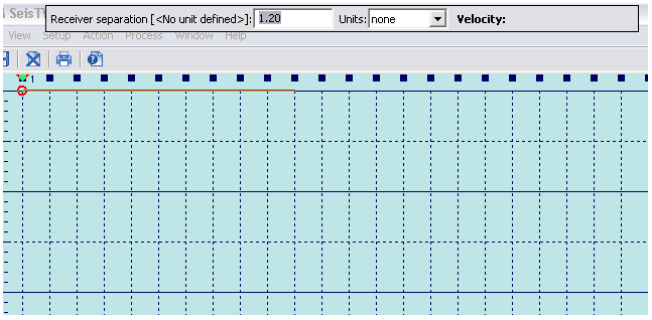
- Opening the *Velocity Analyzer*
  - Press <SHIFT> + <8>
- Closing the *Velocity Analyzer*
  - Press <ESC>
- Moving the *Velocity Marker* (see the figures below)
  - Press <+> to move the line down
  - Press <-> to move the line up
  - Press <SHIFT> + <+> to move the line to the right
  - Press <SHIFT> + <-> to move the line to the left

The end of the *Velocity Marker* that has the little circle is the anchor point of the line. The other end is called the free end. This end moves when the *Velocity Marker* is being tilted and stretched.

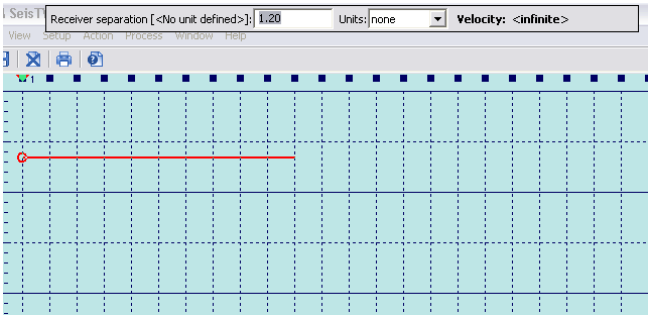
- Tilting the *Velocity Marker* (see the figures below)
  - Press <CTR> + <RIGHT> to move the free end to the right
  - Press <CTR> + <LEFT> to move the free end to the left

- Press <CTR> + <DOWN> to move the free end down
- Press <CTR> + <UP> to move the free end up

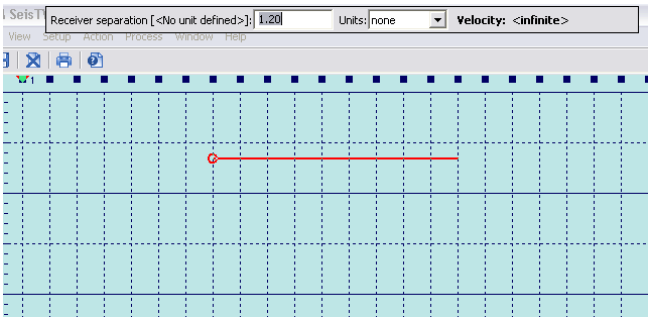
Start position



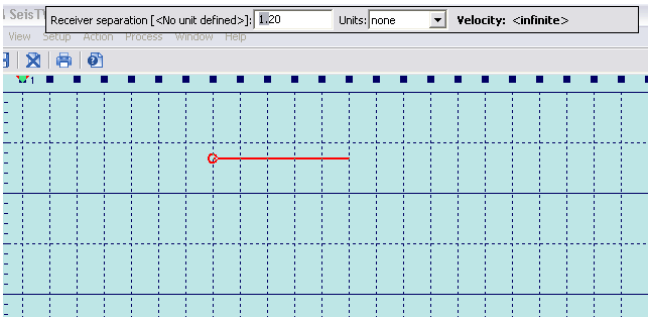
Moved down



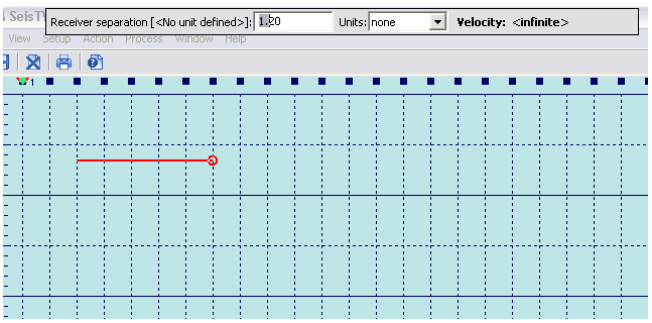
Moved to the right



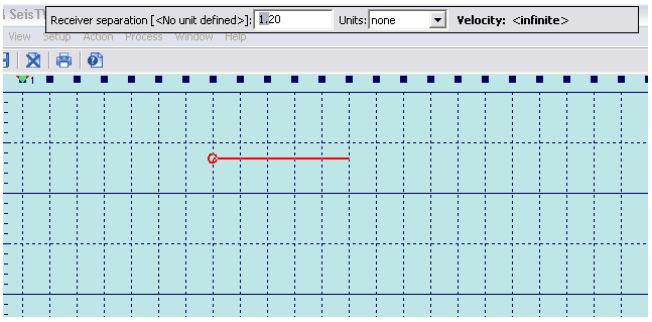
Free end to the left



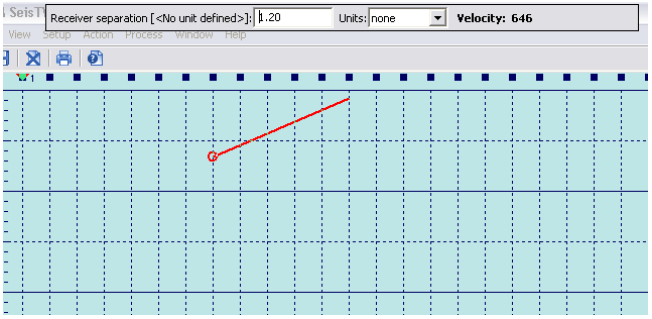
Free end further to the left



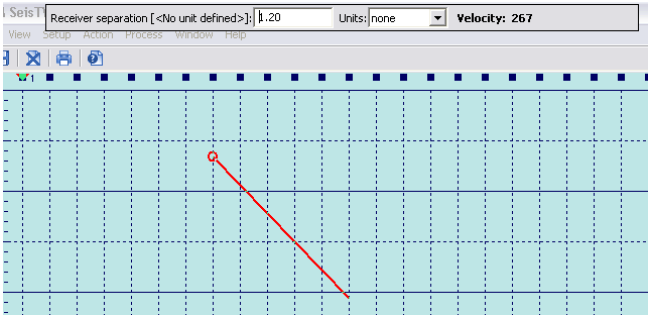
Free end to the right



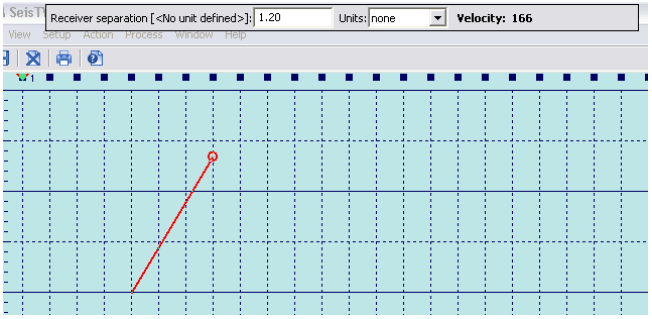
Free end up



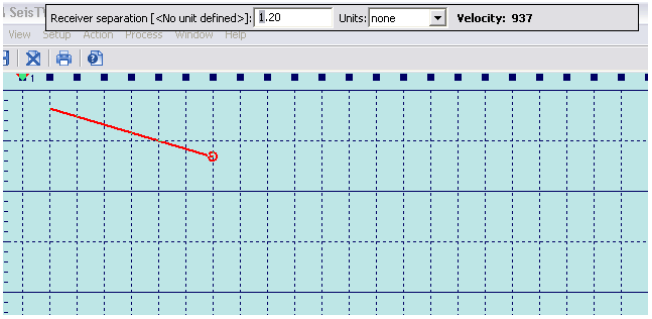
Free end down



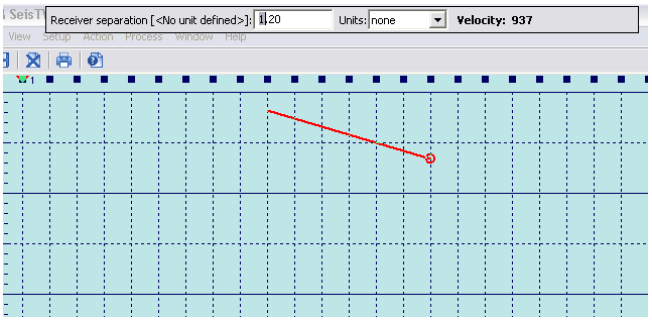
Free end left



Free end up



Moved to the right



5 Data Processing

The data processing discussed below works on data in memory, not to a previously saved file.

Note!	If a *Save* command is done then previously stored data will be overwritten and lost. Use *Save As* and choose a different file name to keep both the original data and the processed data

5.1 Unfilter Data

The *Unfilter data* menu item on the data *Context Menu* (Figure 31) discards any processing results and reads back the original data from disk.

5.2 First Breaks

Chapter 14.1 Refraction discusses *First Breaks / First Arrivals*.

These entries are accessed via a sub menu in the *Context Menu* (Figure 56).

Figure 56 The First Breaks submenu

There are two formats available for pick files, ABEM's FIR-format, and REFLEXW's pck-format. Choose format before loading or saving the first break picks.

More information about the first arrival file format (FIR-format, *FIrst aRrival*) can be found in chapter 13 Appendix E. The First Arrivals File Format (FIR).

Menu item		Description
Auto pick	-	Performs an automatic first break pick. Automatic computing of first arrivals works best on data with small pre-signal noise. You should always check the picked arrivals and edit any bad picks. If there are one or more picks for this record, you will be warned before times are picked automatically.
Load picks	-	Loads the first break picks from a pick file to the currently active record. If there are more picks in the pick file than traces in the record, the superfluous picks are discarded. If there are fewer picks, only the first traces loads the picks
Save picks	-	Saves the first break picks to a text file in the current directory.
Clear picks	-	Clears the first break picks

5.3 FIR Filter

The *FIR* filters (Finite Impulse Response) are used to reduce noise from the recorded data.

Note!	The abbreviation FIR in this filter context is not the same as FIR used in the first breaks context

The *FIR filter* dialog (Figure 57) is accessed from the data *Context Menu* (Figure 31).

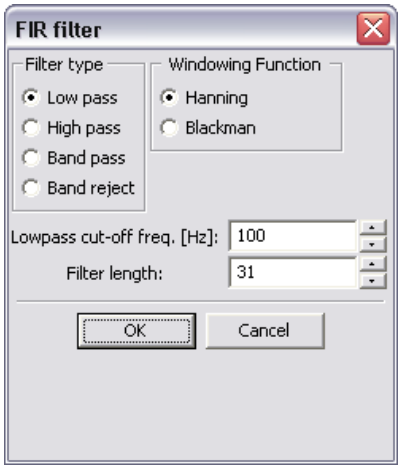


Figure 57 The FIR filter dialog

Clicking OK will apply the filter to the current data.

Setting	Description
Filter type	- Selects the type of filter to apply to data. The following types are available: **Name** — **Description** Low pass — Rejects frequencies higher than the high cut-off High pass — Rejects frequencies lower than the low cutoff Band pass — Rejects frequencies lower than the low cut-off and higher than the high cut-off Band reject — Rejects frequencies between the low cut-off and high cut-off
Windowing function	- Data windowing function to apply to the data when filtering. Available values are: Hanning and Blackman
Cut-off frequencies	- The cut-off frequencies are specified as the frequency where the pass band signal has been reduced by 3 dB and the transition band starts. The low- and high pass filters only specifies a single cut-off frequency, while the band pass and band reject filters specifies two frequencies, low- and high cut-off
Filter length	- The number of filter coefficients used to realize the filter. The longer the filter, the steeper its slope, i.e. it will cut the signal more abruptly. A longer filter also takes longer to apply, especially to long records

5.4 Cross Correlate

Chapter 14.6 Vibroseis discusses the use of cross correlation.

Selecting the *Cross correlate* menu item from the data *Context Menu* (Figure 31) opens the *Reference trace selection* dialog (Figure 58).

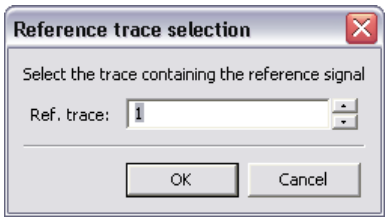


Figure 58 The Reference trace selection dialog

Setting	Description
Ref. trace	- Value range: 1 – number of channels

Enter the trace number that was used for the reference signal and then press OK. The cross correlation may take several minutes, so be patient. The *Cross correlation* progressing status dialog will be shown (Figure 59). The progress is shown partly as a progress bar and partly time values. Updates to the dialog are a bit uneven but occur every 10th to 15th second.

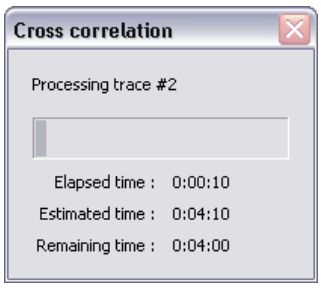


Figure 59 The Cross correlation dialog

The next two figures (Figure 60 and Figure 61) first display raw data from a record acquired using vibration seismic and then after cross correlation has been applied to the data.

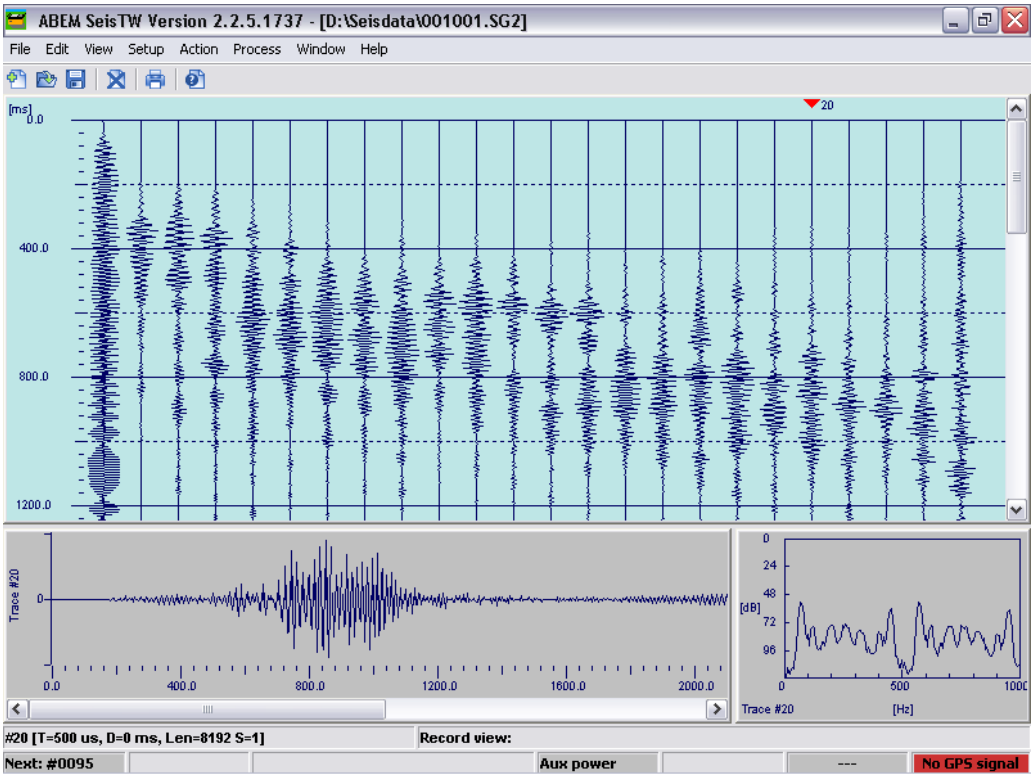


Figure 60 Opened record – before processing

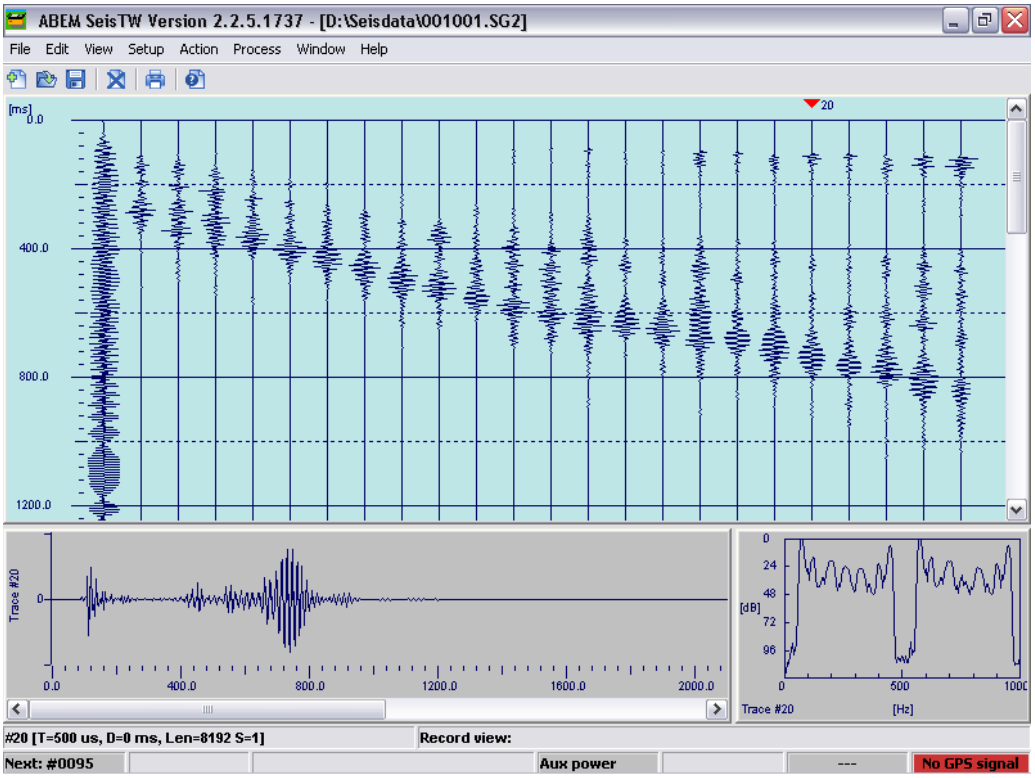


Figure 61 The same record – now cross-correlated

5.5 Moving Average

Moving average is used to analyze a set of data points by creating a series of averages of different subsets of the full data set. It can be used to smooth out short-term fluctuations and highlight longer-term trends.

Selecting the *Moving Average* menu item from the data C*ontext Menu* (Figure 31) opens the *Enter filter length* dialog (Figure 62).

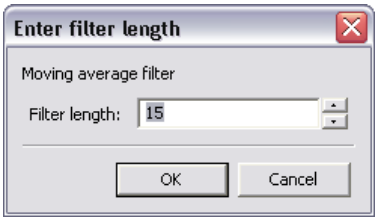


Figure 62 The Enter filter length dialog

Setting	Description
Filter length - Value range: 1 - 1023	

Enter the wanted filter length (the number of samples to use) and then press OK.

The next two figures (Figure 63 and Figure 64) first display raw data from a record acquired using vibration seismic and then after being processed with a moving average filter with a filter length of 15.

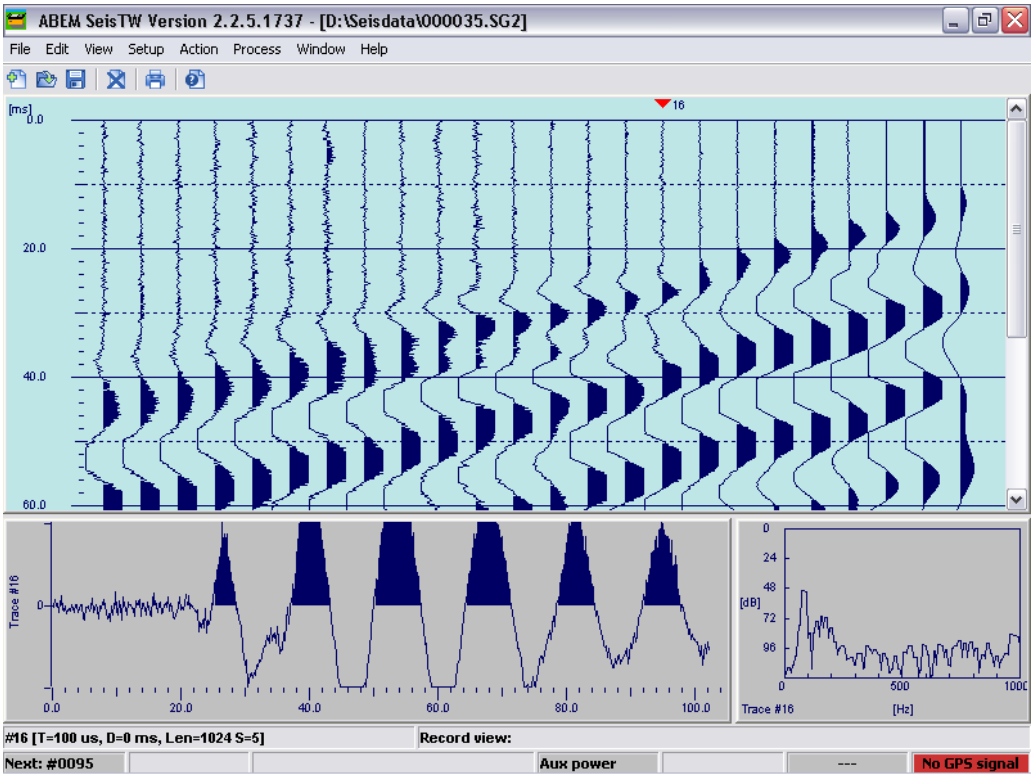


Figure 63 Opened record – before processing

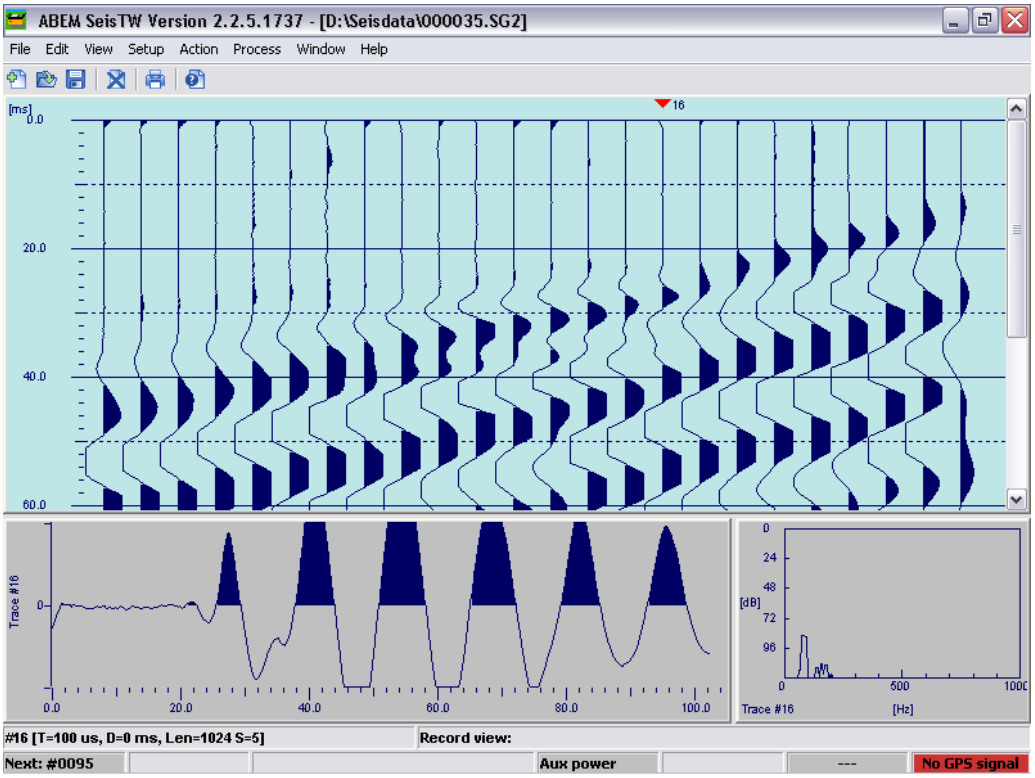


Figure 64 The same record – after moving average filter

6 Triggering Methods

To make a recording with the Terraloc Pro seismic system, an initiating trigger signal is required. The trigger pulse defines the start of the data recording and is the reference for all timing.

6.1 Make/Break Switch Input

The system will trigger if the wires of the trigger cable are shorted together (make switch), or if the shorted wires are opened (break switch).

When you use explosives, one trigger method is to put a few turns of wire around the charge. The wire is cut by the explosion and triggers the seismograph (break switch). You can also twist a pair of insulated wires together and insert the twisted part into the dynamite. The explosion will compress the wires and crush/melt the insulation causing the leads of the wires to short together. This will trigger the seismograph (make switch).

Besides, this make switch triggering method can be applied when you use falling weight or hammer as energy source. However, you must use a metallic shock plate and the falling weight or the hammerhead must be made out of metal. Connect one lead of the trigger wire to the shock plate and the other lead to the falling weight or hammerhead. When the hammer hits the shock plate, the trigger circuit is shorted and the instrument triggers.

6.2 Using the Trigger Coil

If you want to trigger Terraloc Pro with the ignition current going out to the charge, you can use the Trigger Coil (current detector unit) included in the Terraloc Pro accessories. To use this you merely feed one of the two shot wires through the hole in the trigger coil. The trigger coil is either connected directly to the trigger input or to the extension connectors on the trigger cable reel. Then set the Terraloc Pro in the "Analog" trigger input mode with the sensitivity control set at about 50 %. When the charge is fired, the ignition current will trigger Terraloc Pro instantly. The current pickup trigger method is very convenient since you only need to bring the shot cable to the shot hole.

Note!	You have to use (seismic) blasting caps with no built-in delay to be able to use this method. If you use ordinary blasting caps the ignition delay will be included in your record. There are seismic blasting caps of the safety type available. Their delay is only some 50 µs if fired with a high power-blasting machine.

6.3 Radio Triggering

In case you need to trigger the Terraloc Pro in places where you cannot use a trigger cable, you can use a simple radio equipment to transmit the trigger pulse.

7 Measurement

7.1 Basic Operations

See chapter 3 Quick Start for an introduction to the most basic operations on the Terraloc Pro.

- Initiating

  – Press <ARM>

  Or

  – Press <CTR> + <SPACE> to open the *Quick Menu*

  – Press <1> to select *New*

  – Press <ENT>

- Arming

  – Press <ARM>

- Trigging

  – Press <CTR> + <ARM> to force a trig

  Or

  – Set up an automatic trigging (chapter 4.6.5.2)

- Saving

  – Press <SAVE> to save the current file (prompting for overwrite if the file already exists)

  Or

  – Press <SHIFT> + <SAVE> to open a “Save As”-dialog

  Or

  – Press <CTR> + <SAVE> to force a save of the current file (overwriting any existing file)

- Disarming

  – Press <ESC> to disarm an armed instrument

- Delete recorded data

  – Press <BACKSPACE> to delete the last acquired shot

  – Or

  – Press <ESC> to show the *Clear Traces Menu*

  – Press <1> or <2> or <3> to delete the wanted data

- Open a stored record
  - Press <CTR> + <SPACE> to open the *Quick Menu*
  - Press <2>
  - Press <SHIFT> + <TAB> to move focus to the file list
  - Press <ARROWS> to select the wanted file
  - Press <ENTER>

- Close the current record
  - Press <CTR> + <SPACE> to open the *Quick Menu*
  - Press <3>

- Switch between opened records
  - Press <CTR> + <TAB> to switch forward
  - Press <CTR> + <SHIFT> + <TAB> to switch backward

7.2 Data Transfer

It is highly advisable to make backup copies of recorded data. As with every computerized system there is always a slight risk that data could be lost due to hardware failure or corrupted data. ABEM cannot take responsibility for recorded data that is lost.

7.2.1 Data Transfer Using the Ethernet Port

This is a function of Microsoft Windows XP Professional and not a specific function of the ABEM Terraloc Pro. Hence, ABEM cannot be responsible for any problems that may occur that isn't associated with the Terraloc Pro hardware or measurement programs developed by ABEM.

File transfers from your Terraloc Pro to a PC can be done using a network cable. You will also need an external USB-keyboard and USB-mouse for the Terraloc Pro. These parts are supplied with the Terraloc Pro at delivery.

Note!	If the Terraloc Pro is connected directly to a PC, rather than connected to an existing LAN (Local Area Network), it might be necessary to use a crossed network cable. This is not supplied with the instrument but is available in most computer stores.

One way to do file transfer over the network cable connection in Windows is to set up a small network and allow sharing of a folder, which measurement data can be copied to. By default the Terraloc Pro is set up with the computer name *Terraloc Pro* and to be a member of a workgroup called *WORKGROUP*. The IP number of the Terraloc Pro can be found by writing the "ipconfig" command in the command prompt accessible under "Start menu /All programs / Accessories".

To access the shared folder in the Terraloc Pro from the PC, go to “Start / Search / select Computers or people” from the menu on the left and then “A computer on the network”. At this point enter the IP number of the Terraloc Pro in the Computer name search field and click the search button. You may have to login, but then you should be able to access the files.

Note!	There are security issues with sharing folders. Never put any sensitive data in a shared folder since it is easy accessible when the Terraloc Pro is connected to a network or to the Internet. It is also advisable to only allow reading of files and not writing.

Another option is to configure the Terraloc Pro for use in a normal office network (LAN) wired or wireless (WiFi); this will not be described in this manual.

7.2.2 Data Transfer Using an USB Memory Stick/Drive

Terraloc Pro has built in USB 2.0 ports for fast and easy file copying to a USB memory stick/hard disk.

7.3 Optimizing

Many of the settings you select affect the performance of the system. You can set up the system to do the data acquisition as fast as possible, or to give you as much information during the acquisition as possible, which often means a more secure operation.

7.3.1 For Speed

Sometimes, for example in marine seismic surveys, it is important to obtain fast data acquisition. There are some operations that can be modified, or even skipped, to enhance the acquisition speed. Still, there are some operations that are fixed, and to this category belong the actual data acquisition (sampling procedure), transfer of the data from acquisition memory to trace memory, and writing of the data to disk.

However, the following should be considered:

- Do not display data after shooting, i.e. set *Stack Mode* to "Fast stack" since scaling of traces takes a considerable time (chapter 4.6.5.1).
- Use as short records as possible (*No of samples*) (chapter 4.6.5.1).

7.3.2 For Security

When you optimize for security, you set the instrument up to give you as much information about the data acquisition as possible. This means that, e.g. data and progress are displayed.

- Set *Stack Mode* to "Preview" or "Single" (chapter 4.6.5.1).
- Use the noise monitor if you are in “´Single” *Stack Mode* (chapter 4.6.5.3).

8 Troubleshotting and Diagnostics

Although great care has been taken to make Terraloc Pro as reliable as possible, there is always a small risk that something does not work properly. Should you have trouble getting things to work please refer to this chapter. This is a guide to common problems and how to work them out.

8.1 General SeisTW Program Problems

These errors are generally related to the software.

8.1.1 The Program Does Not Start

There should normally be no problem starting SeisTW in the Terraloc Pro once it has been installed. However, if SeisTW does not start when starting the instrument the program might need to be reinstalled. Follow the installation instructions in 11 Appendix C. SeisTW Installation.

8.2 Data Acquisition Problems

The data acquisition problems can range from errors in the setting up of the system for measurement, over hardware problems, to errors in the settings in the software.

8.2.1 Terraloc Pro Only Waits For Confirmation When Arming

If the instrument shows the status message "<<<Pending ARM ...>>>" when you try to arm the instrument, it means that *External Arm Input* mode is set to TTL Rising edge or TTL Falling edge. If it is, it will wait for an external arm signal to arrive before it arms itself. This is used when you interconnect two or more Terraloc Pro instruments (chapter 2.6).

If you use one Terraloc Pro only, no external arm will arrive, hence the Terraloc Pro never arms (unless you have some other external device that confirms the arm command). Set *External Arm Input* to Off and the arming will be normal (chapter 4.6.5.2).

8.2.2 Dead Channels/Traces

Check the *Receiver Spread* dialog for the settings of the "Stack On" and "Trace On" parameters (chapter 4.6.8). You should also check the reference channel setting in the *Layout Geometry* dialog (chapter 4.6.9).

8.2.3 Data Is Not Displayed

Check if you have selected Fast Stack as stacking mode, as this causes data not to be displayed on the screen (chapter 4.6.5.1). In case of Auto Stack, Preview and Single, check that the "Trace" parameters in the *Receiver Spread* dialog are activated (chapter 4.6.8).

8.2.4 Large Offset

Check offset level and do not worry if it is less than 2000 units.

8.2.5 Incorrect Channel Order

Either one cable, at least, has been reversed in the layout or the channel assignments are erroneous. Check the cable and/or the channel assignments in the *Receiver Spread* dialog (chapter 4.6.8). Please be aware that a reversed cable can be corrected for in this dialog.

8.3 Trigger Problems

Correct triggering is essential for the quality of the data from the acquisition, especially when it comes to timing. This means that you should be very careful when selecting triggering method and setting up the triggering system. It may not always be obvious that there is something wrong with the trigger.

8.3.1 Triggering Too Late or Too Early

Erroneous setting of the trigger sensitivity usually causes this when analog triggering is used. Adjust the sensitivity level so the trigger pulse is detected correctly (chapter 4.6.5.2).

8.3.2 Spurious Triggering

This is usually caused by too high trigger sensitivity, resulting in triggering on pretrig event noise. Adjust the sensitivity level so the trigger pulse is detected correctly (chapter 4.6.5.2).

If you are using radio triggering, also check the signal levels of the transmitter and receiver respectively.

8.3.3 Unable To Trigger

The trigger sensitivity might have been set too low, or the type of trigger input does not agree with the trigger method used. Check the trigger settings (chapter 4.6.5.2) and the trigger cable; there may be a break in the cable or a bad connection somewhere.

Select "Make/Break" trig input mode (the trigger input level should be about 50%) and try to short the trigger input by a bare wire. The instrument should trigger when you make or when you break connection. If the instrument does not trigger, then you might have a fault in the internal triggering electronics.

8.3.4 Triggering Immediately When Arming

If you are using analog triggering, the trig sensitivity might have been set too high. At the highest sensitivity level, even internal electronic circuitry noise may cause triggering (chapter 4.6.5.2).

8.4 Remote Diagnostics (VPN)

The Terraloc Pro can be connected to ABEM for remote diagnostics over a VPN (Virtual Private Network). To connect the instrument to a VPN you need a standard Ethernet based TCP/IP LAN (Local Area Network) that is connected to the Internet. The instrument is connected to the LAN either wired with a RJ-45 cable or wireless with WiFi.

If the LAN has a DHCP service, the instrument will acquire an IP number and most likely the other required network settings from the DHCP server when the network

service starts. Note that the DHCP server must allow unregistered MAC addresses. If it does not, the instrument's MAC address must be registered in it. Please contact your local network administrator if this is necessary.

Restrictions: The LAN router or firewall must not block outgoing traffic on port 1194, and must allow incoming traffic that is initiated from inside the LAN to be returned to the instrument. It must also allow VPN communication with the ABEM office (www.abemoffice.com). Further, if the LAN is using NAT, it must not use the private IP network 10.17.23.x since the VPN will be using it. Most office LANs will meet these specifications.

Please note: Some countries/companies have firewall rules that blocks access to this type of service.

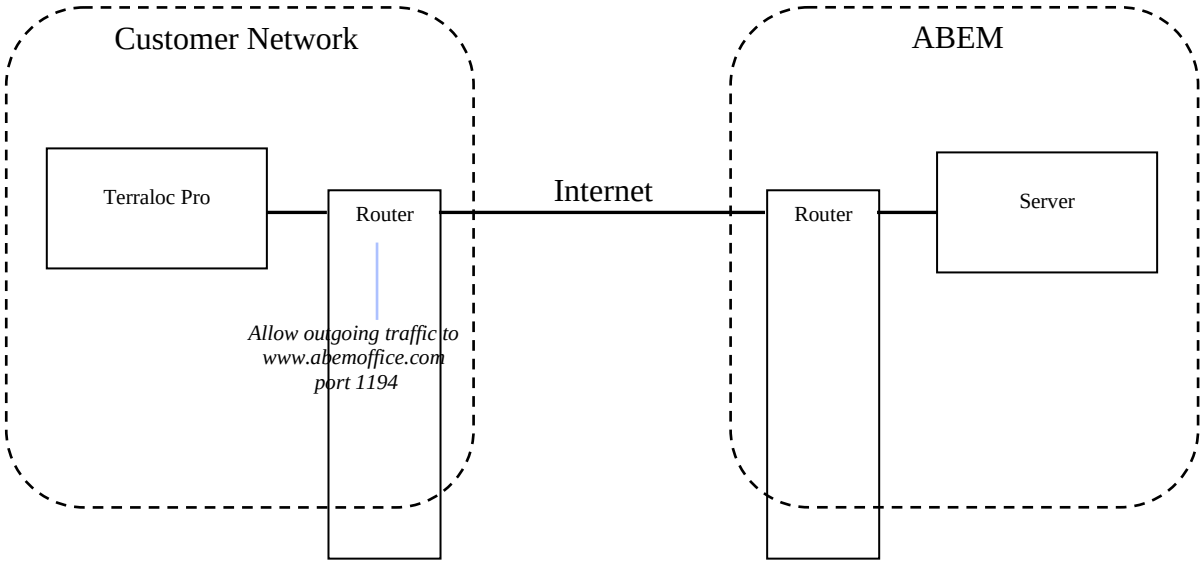
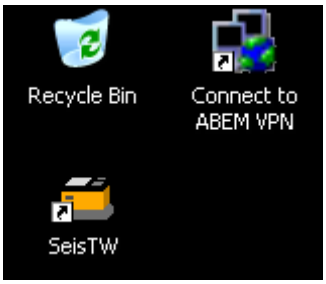
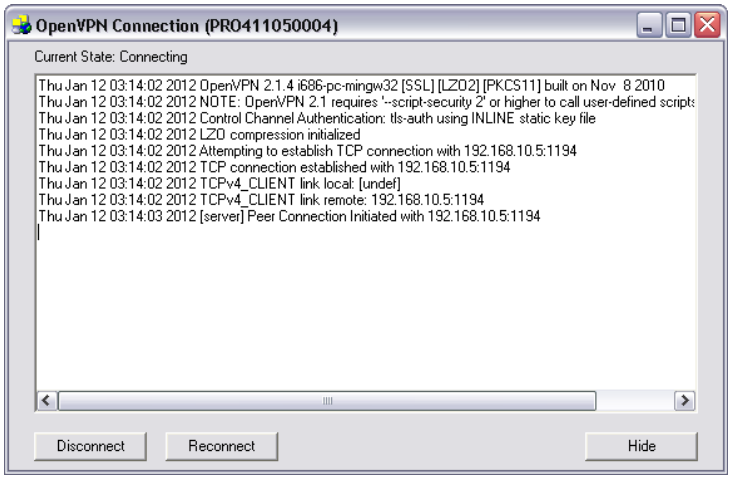
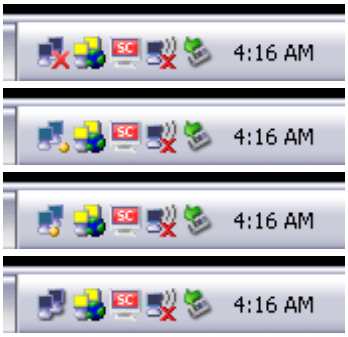
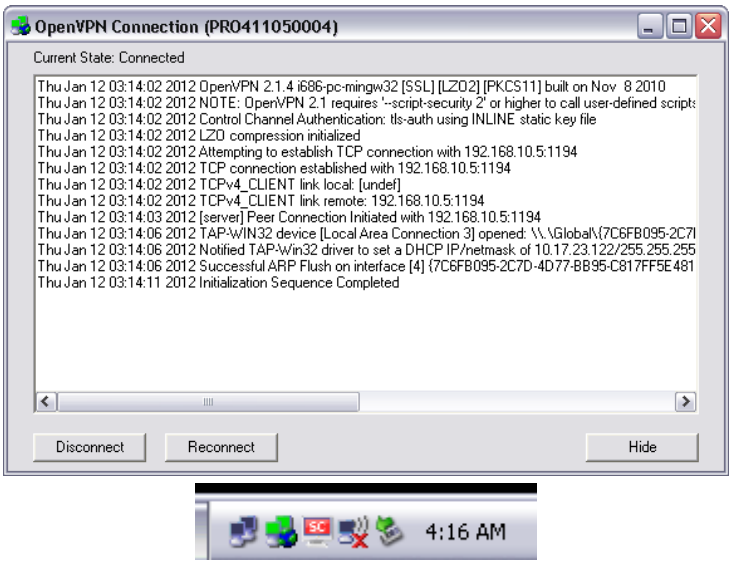


Figure 65 Remote diagnostics over VPN

If you are not familiar with the terminology in this section, and experience problems with the connection, please contact your local network administrator.

- Establishing a connection

– Double-click on the desktop icon named *Connect to ABEM VPN*	

The instrument will try to establish a connection	
Tray icons will change like this during the connection phase	
Connection established!	

- Disconnecting

– Right-click on the OpenVPN tray icon to open its context menu	

– Select the *Disconnect* menu item Connection disconnected!	

8.5 In Case of Malfunction

In case of malfunction please carry out applicable tests as described in this manual. If it is not possible to find the cause of the problem, follow the instructions in Section 8.4 Remote Diagnostics (VPN) to connect the instrument to ABEM's technical support, and send a description of the problem via e-mail to *support@guidelinegeo.com*.

Should a fault occur that is not correctable on site, please send full details to ABEM. It is essential that the instrument type and serial number is included and, if possible, the original ABEM delivery number. On receipt of this information, disposition instructions will be sent by return. Freight to ABEM must be prepaid. For damage or repairs outside the terms of the Warranty, ABEM will submit an estimate before putting the work in hand.

Be sure to fill in the warranty registration card (included with the equipment) correctly and return it to ABEM promptly. This will help us process any claims that may be made under the warranty. It will also help us keeping you informed about for instance free software upgrades. ABEM welcomes your response at any time. Please let us know your name and address, and the serial number of the instrument.

9 Appendix A. Technical Specification

General

Number of channels	12, 24 or 48
Additional channels	Easily obtained by linking two or more units together
Up-hole channel	Yes, 2 additional independent
Sampling rate (selectable)	100 sps – 50 ksps (20 μs – 10 ms)
Record length (selectable)	Up to 480 k samples / ch. equivalent to: 9,6 s – 80 min
Pre-trig record (selectable)	0 – 100 % of record length
Delay time	Up to 2 minutes
Stacking	32 bits, up to 999 impacts
Unstack	Remove last shot from stack
Trigger inputs	Trigger coil, make/break, geophone, TTL
A/D converter resolution	24 bits
Dynamic range	(theoretical/measured) 144 dB / >120 dB
Max input signal/ impedance	0,5 Vpp/3 kΩ, 5 Vpp/20 kΩ, 12,5 Vpp/3 kΩ, hi impedance
Frequency range	DC to 20 kHz hi imp
Total harmonic distortion	0,0005%
Crosstalk	-120 dB
Noise monitor	Amplitude
Anti-alias filters	Set automatically based on sampling rate
Connectors	NK-27 / KPT 55
Power	10 – 34 V DC external power, 12 V 8Ah NiMh internal battery
Power consumption	30/60 W (man/acq)
Ambient temp (operating)	-20 to + 55 °C
Ambient temp (storage)	-30 to + 70 °C
Casing	Rugged Al alloy; Meets IEC IP 66
Weight, 24 channels	10 kg
Weight, 48 channels	11 kg
Dimensions (W x L x H)	39 x 21 x 32 cm

Post recording features

Digital filters	Band-, low-, high- pass band-reject, remove DC offset
Spectrum analysis	Any single trace, FFT analysis
Velocity Analysis	On-screen analysis of refractor velocity
First-arrivals picking	Automatic or manual. Times can be saved with record.
Pre-stack correlation	Yes, cross correlation with reference or any other ch.

Processor, RAM and hard disk

Processor	Low power Intel Atom, 1,6 GHz
Operating System	Windows XP Pro
Internal RAM	2GB (DDR SO-DIMM module)
Hard disk capacity	at least 100 GB
Display	8,4“ Active TFT LCD, full color, daylight visible, 800x600
External display port	VGA output
I / O port	3 x USB 2.0 ports
Network interface	1 x IEEE 802.3 TP-10/100/1000 (RJ-45 IP67) 2xTP-10/100 KPT 08 Inbuilt WLAN Antenna in handle

10 Appendix B. Connectors

10.1 Seismic Input Connectors

10.1.1 12 and 24 Channel Terraloc Pro

Connector type:

Cannon NK-27-32P Panel connector (mating side) (fits to NK-27-21C-1/2 ” cable connector)

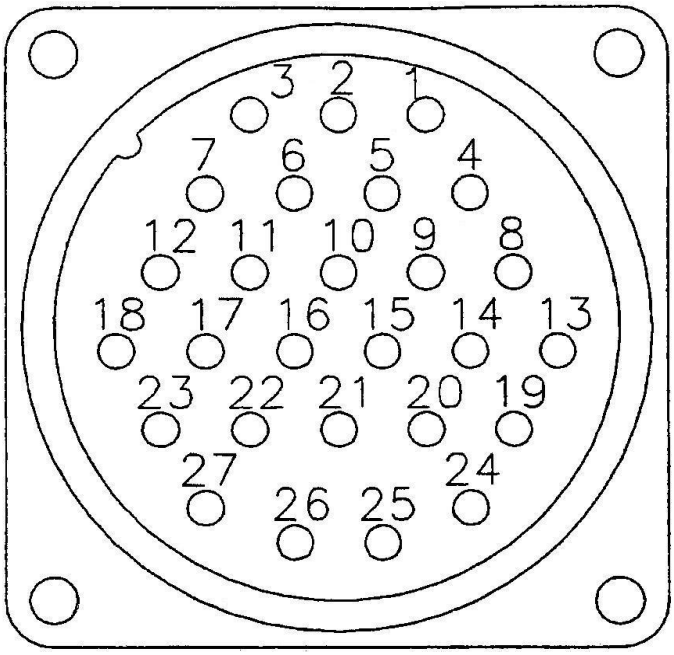


Figure 66 Input Connector 12- and 24-channel Terraloc Pro

Connector 1-12		Connector 13-24	
Pin	Channel	Pin	Channel
1	1+	1	13+
2	1-	2	13-
3	2+	3	14+
4	2-	4	14-
“	“	“	“
“	“	“	“
23	12+	23	24+
24	12-	24	24-

10.1.2 48 Channel Terraloc Pro

Connector type:

Cannon KPT-02-A22-55P Panel connector (mating side) (fits to KPT-06 A22-55S cable connector)

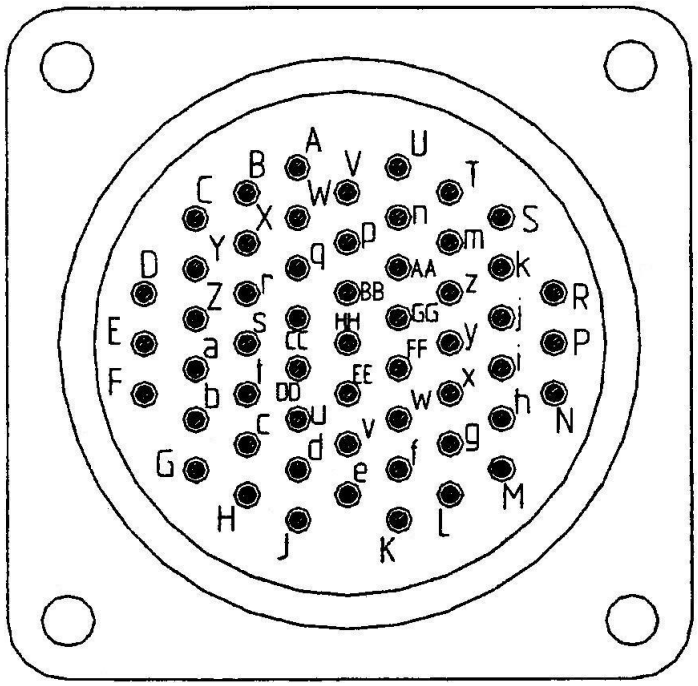


Figure 67 Input Connector 48-channel Terraloc Pro

Connector 1-24		Connector 25-48	
Pin	Channel	Pin	Channel
A	24+	A	25+
B	24-	B	25-
C	23+	C	26+
D	23-	D	26-
“	“	“	“
“	“	“	“
Z	13+	Z	36+
a	13-	a	36-
b	12+	b	37+
c	12-	c	37-
“	“	“	“
“	“	“	“
z	1+	z	48+
AA	1-	AA	48-

10.2 Power Connector

Connector type: Tyco Electronics 788189-02 (mating side), (fits to 788188-1 cable connector).

(Mating side view)

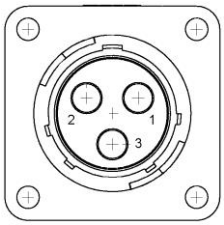


Figure 68 Power Connector

1 Positive power supply (+)

2 Negative power supply (-)

10.3 TTL Arm/Trig Connector

Connector type: KPT 02-E10-6P (fits to KPT 06-E10-6S cable connector.)

(Mating side view)

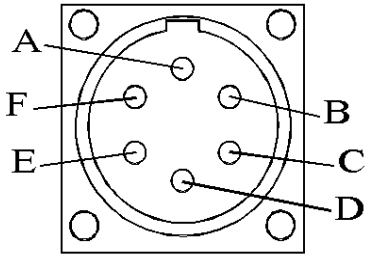


Figure 69 TTL Arm/Trig Connector

A	Trigger Output
B	Arm Input
C	Trigger Input
D	GND (Ground)
E	No Connection
F	Arm Output

TTL stands for Transistor-Transistor-Logic. It is used in connection to digital signals. A digital signal is considered to be either a logical 0 or a logical 1 (hereafter only called 0 and 1). Physically a 0 corresponds to a voltage of 0-0.7 V, while a 1 corresponds to a voltage of 2.8-5.0 V. Alternatively, a 0 might be called "low", and a 1 called "high".

10.4 Alarm Connector

Connector type: KPT 02-E08-4P (fits to KPT 06-E08-4S cable connector.)

(Mating side view)

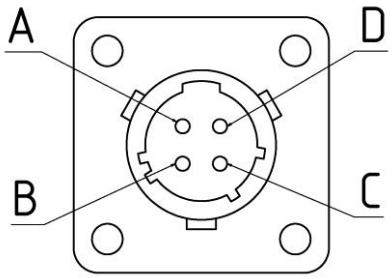


Figure 70 Alarm Connector

A Alarm output +12V at alarm (output max. 0.5A)

B Alarm relay output pole 1

C Alarm relay output pole 2

D Alarm output ground

10.5 Cascade Connector

Connector type: KPT 02-E12-8P (fits to KPT 06-E12-8S cable connector.)

(Mating side view)

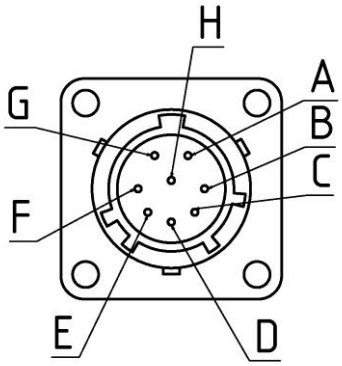


Figure 71 Cascade Connector

A Tx+ 1
B Rx+ 1
C Tx+ 2
D Rx+ 2
E Tx- 1
F Rx- 1
G Tx- 2
H Rx- 2

The Cascade connector is used when measurements are done with several Terraloc Pros. Connection between instruments is made with a special Cascade connection cable.

11 Appendix C. SeisTW Installation

Terraloc Pro is delivered with all necessary software installed at the factory. However, if the software needs to be updated, or re-installed, the procedure is described below. When the installation has finished, verify that the SeisTW version is correct, and that the device driver and API version are identical. This information can be found in the About dialog (press <CTR>+<HLP>).

11.1 Install Procedure for SeisTW

Copy the setup file "SetupSeisTW-x.x.x.xxxx.exe" (the x:s represents the version number) to the hard drive of the Terraloc Pro and double-click the file to start the setup procedure. Follow the instructions in the setup wizard and verify that all three boxes are checked to install Terraloc Pro drivers, SeisTW and examples (Figure 72).

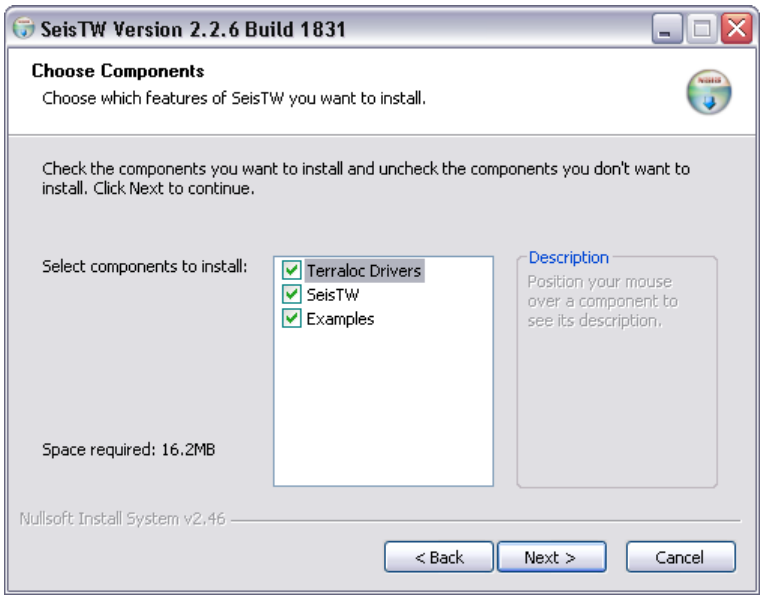


Figure 72 SeisTW Setup – Component choice

Now click on the next button, input the serial number of the instrument and set the number of channels to the number of channels installed in the instrument (Figure 73).

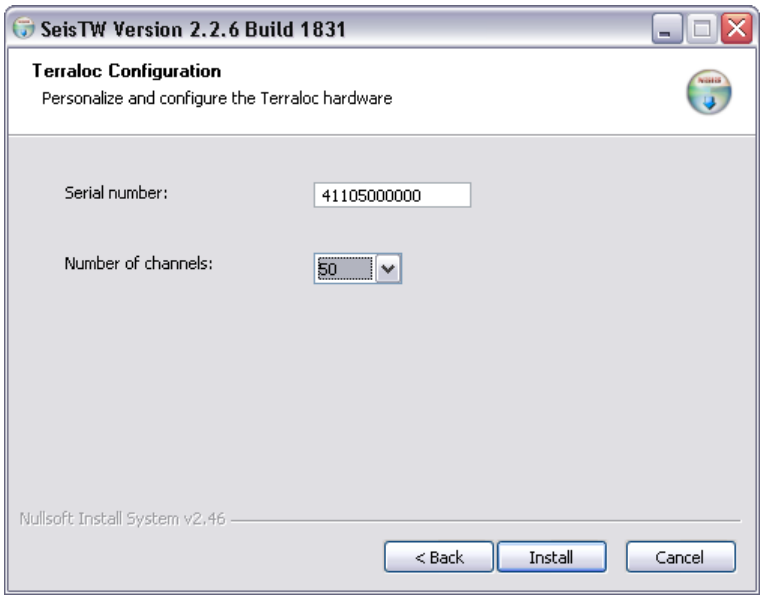


Figure 73 SeisTW Setup – Configuration

Then click on the Install button and the setup program will now install all necessary files for SeisTW (Figure 74).

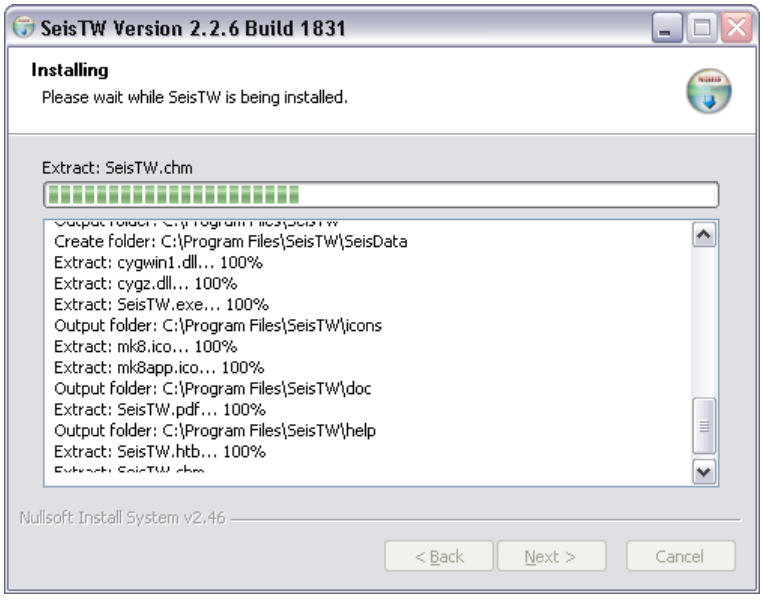


Figure 74 SeisTW Setup – Installation ongoing

Click the Next button when the *Installation Complete* screen is displayed (Figure 75).

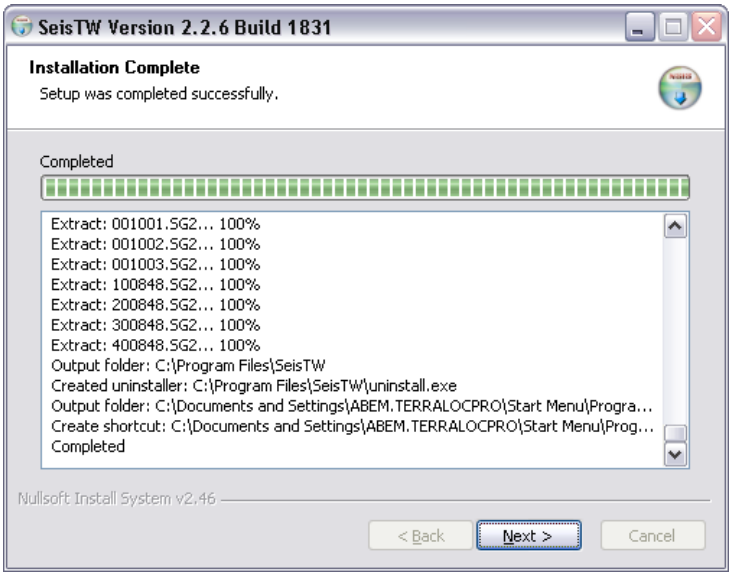


Figure 75 SeisTW Setup – Installation completed

And then click the Finish button (Figure 76).

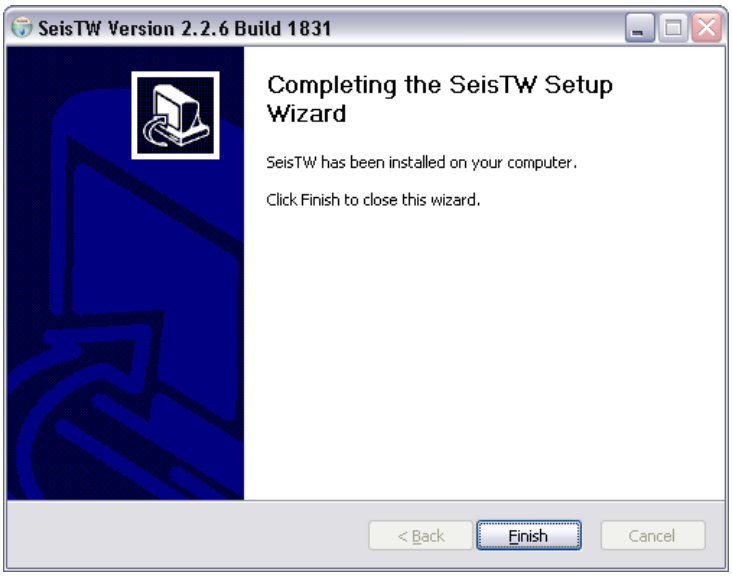


Figure 76 SeisTW Setup – Completing

Click the Yes button to complete the installation procedure.

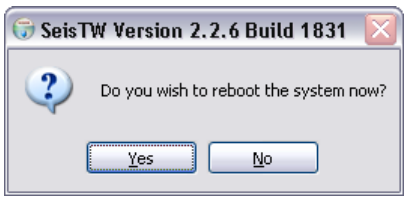


Figure 77 SeisTW Setup – Reboot

The Terraloc Pro will now restart and automatically launch SeisTW.

12 Appendix D. Printout Examples

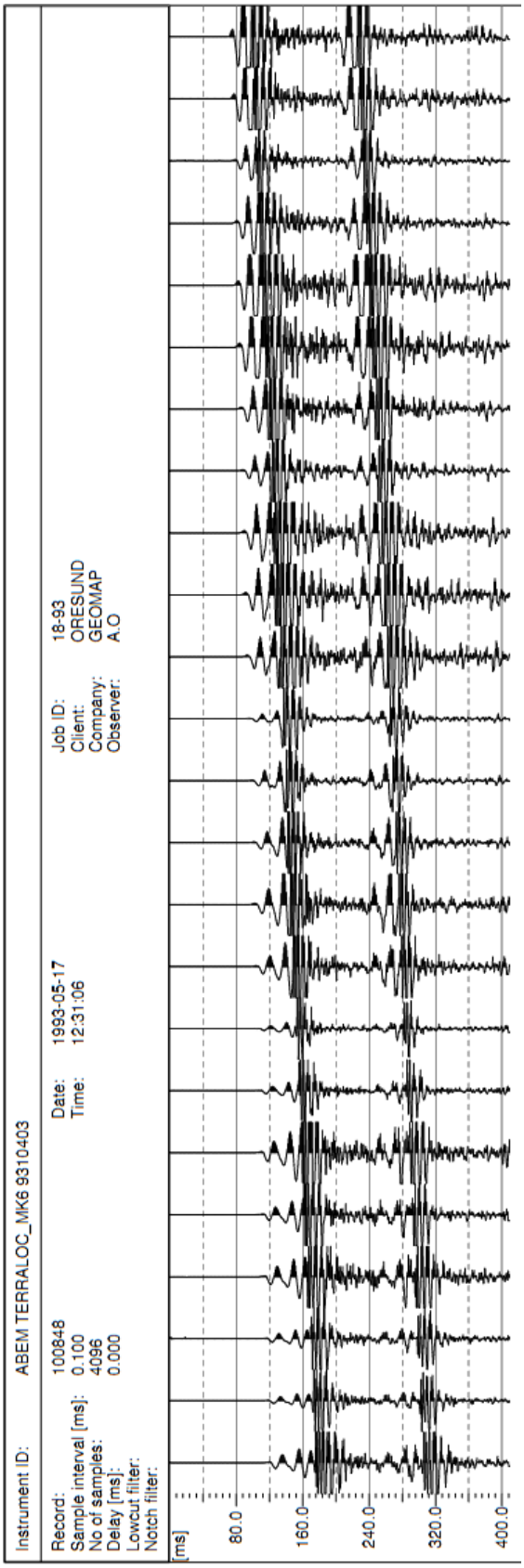


Figure 78 Printout example – Stretch factor 3 (default)

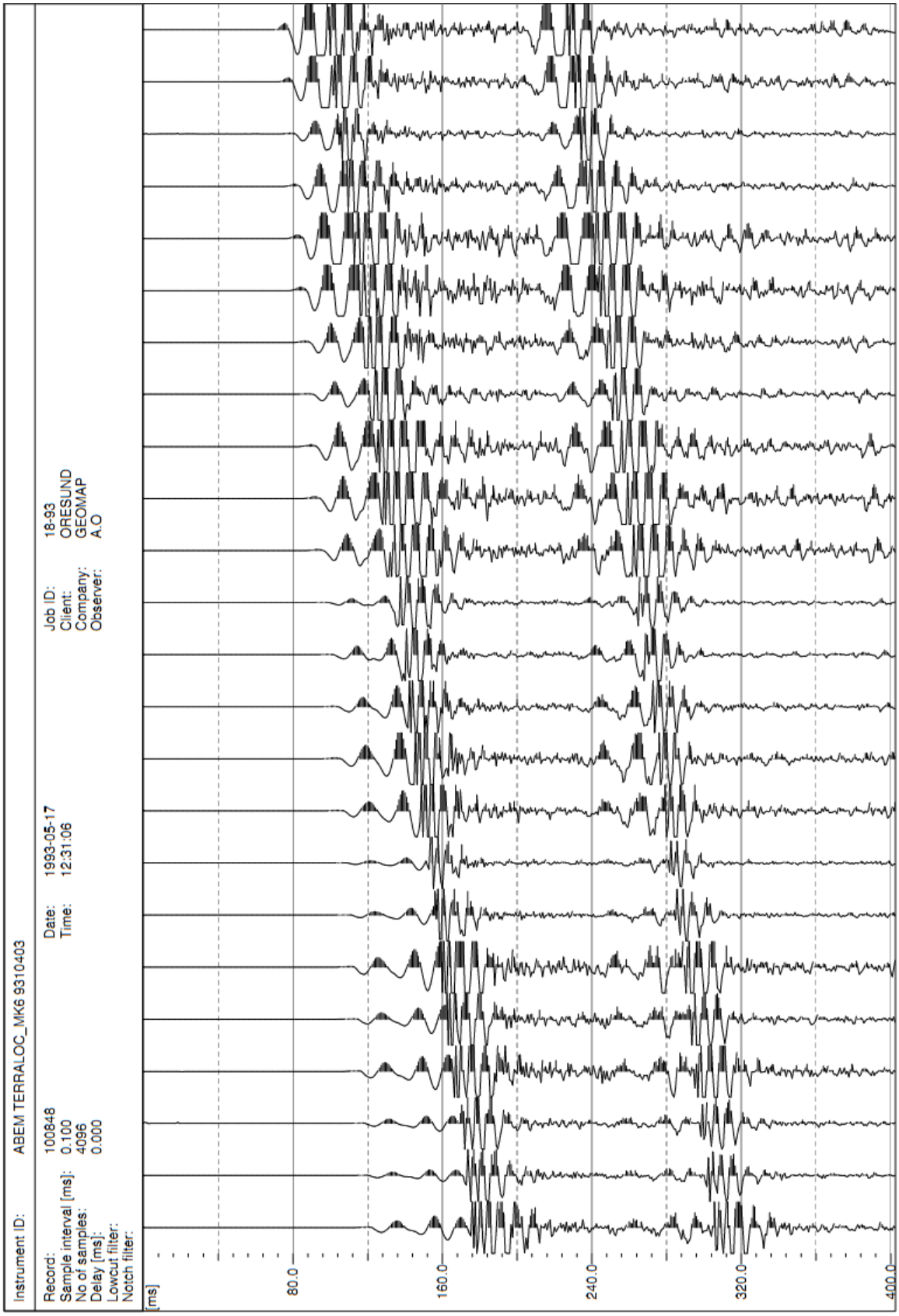


Figure 79 Printout example – Stretch factor 8 (max)

13 Appendix E. The First Arrivals File Format (FIR)

13.1 General

This is an ASCII text file format, containing first arrivals for a record. The file is formatted, so it can be printed on any printer that prints ASCII text. Trace number 1 always starts on line 22. The last trace is succeeded by a line that contains dash characters (-) only. If you are going to edit this file, be sure to keep the proper format.

Following the format for this type of files it is of course possible create new first arrival files manually using a text editor. Be sure however, to save the text in ASCII format and not in any word-processing format (e.g. WordPerfect or Microsoft Word).

13.2 Description

```
<BEGINNING-OF-FILE>
1: Creator: <Instrument - Program version> [Serial number: <xxxxxxx>]
2:
3:  Record:                <record ID>               Date:  <DD/MMM/YYYY>
4:  Sampling interval:     <x.xxx ms>                Time:  <HH/MM/SS>
5:  Number of samples:     <xxxx (xxxx.x ms)>
6:  Delay:                 <xxx ms>
7:  Highpass:              <OFF|xx dB/octave, xx cutoff Hz>
8:  Notch:                 <OFF|ON>
9:  Digital filters:       <None|Bandpass|Highpass...>
10: [Low|high cutoff:      <xx Hz, xx dB/octave>]
11: [high cutoff:          <xx Hz, xx dB/octave>]
12:
13:=================================================================
14:
15: SHOT LOCATION:  X = <x.xxx m>  Y = <x.xxx m>  Z = <x.xxx m>
16:
17:
18: RECEIVER LOCATIONS AND FIRST ARRIVALS:
19: -----------------------------------------------------------------
20: Trace    X (m)  Y(m)   Z(m)   First arrivals (ms)
21: -----------------------------------------------------------------
22:   1      x.xxx  x.xxx  x.xxx        x.xxx
23:   2      x.xxx  x.xxx  x.xxx        x.xxx
24:   3      x.xxx  x.xxx  x.xxx        x.xxx
 .    .        .      .      .           .
 .    .        .      .      .           .
 .    .        .      .      .           .
 .    .        .      .      .           .
 .    .        .      .      .           .
21+N: N      x.xxx  x.xxx  x.xxx        x.xxx
22+N: -----------------------------------------------------------------
<END-OF-FILE>
```

<> Represents a value

[] Denotes optional text

| Delimits possible values

14 Appendix F. Seismic Methods

There are a variety of seismic methods used. The objective of the survey controls which specific method to use. This section will give you an overview of some commonly used methods. Please refer to the bibliography at the end of the manual. If a more detailed and thorough description of seismic methods is needed then Butler (2005) can be recommended as it is relatively new and has an extensive and updated listing of references.

In the refraction and reflection methods there is usually a division between shallow and deep surveys.

14.1 Refraction

The objective is to find out the arrival times of the head waves to map the depth to the refractors in which the waves travel. The refraction method is based on the assumption that the earth is made of layers of materials that increase in seismic velocity with each successively deeper layer. The key element is that an incident ray is critically refracted along the boundaries between layers, before returning to the surface. From the first arrival times it is possible to calculate the seismic velocity for each layer and the depth to the boundaries. The seismic velocity gives information about material properties, and what kind of material comprises each layer. Additionally, frequency analysis of the recorded signals can give more information about the material properties.

The principles for seismic refraction techniques can be found in most geophysical textbooks. For a more detailed description of both theory and practice, see Sjögren (1984).

Investigations performed with the refraction method can yield a variety of reliable data such as depth of various overburden layers, depth to bedrock, rock quality, soil compositions and solidity, rip ability, excavatability, water tables and rock structure.

The refraction seismic method can be used for a wide range of applications, for example:

Underground	Tunnels and their entrances, machinery halls, gas and oil storage facilities, air raid shelters
Foundations	Heavy industrial buildings, bridges, harbor quays and breakwaters, dams, piling, airfields
Excavations	Harbor basins and entrances, pipelines, canals, roads, railways
Resource searches	Gravel, sand and quarry sites
Water prospecting	Groundwater table in the overburden, water bearing sections of rock
Ore prospecting	Mineralized weathered zones, buried channels with high mineral content

14.2 Reflection

In this method, the arrival time events are attributed to seismic waves that have been reflected from interfaces where changes in acoustic impedance occur, and of wave shape changes.

The seismic reflection method has mainly been used for deep investigations (depth > 30 m) in oil prospecting. During recent years however, shallow reflection investigations have become common for engineering and environmental purposes. It is now an important complement to refraction investigations, and has even sometimes replaced refraction. The main reasons for the increase in use of the reflection method is the development of lightweight, high-performance seismographs and the possibility of advanced data processing on inexpensive personal computers. Thus, the cost for reflection investigations has decreased considerably.

Both acquisition and processing of reflection data are more complex and time consuming than they are for refraction data.

14.3 Optimum Offset

This is a special case of the seismic reflection method, in which data are recorded with a fixed source-receiver offset. It is a method for shallow investigations. The offset is chosen to be an optimum value (hence the name), and typically, it is a window where the reflection from the target is located between the refracted first arrivals and the ground roll in the seismogram.

14.4 Tomography

The general idea for tomography is that information about the properties of the interior of a region can be obtained through measurements at the boundary. Thus, this is a method for finding the (2-dimensional) distribution of some physical property (e.g. velocity, reflectivity, bulk modulus, etc.). It can involve borehole-to-borehole, surface-to-borehole, or surface-to-surface measurements. The main restriction is that the source and receiver positions, and hence any boreholes, must be confined to the same plane. This plane can have any orientation.

Usually the travel times for a large number of ray paths through the rock volume is measured and, sometimes, even amplitudes (direct or reflected) are analyzed. Then the dataset goes through an inversion process where the spatial distribution of the physical property is estimated. The technique is very computational intensive and is costly because of the need for boreholes.

The final results are usually presented as maps or plots where the values of the physical property are coded in color or grayscale.

An introduction to this method can be found in Worthington (1984).

14.5 VSP

VSP is short for Vertical Seismic Profiling, i.e. measurements with the receivers located in a borehole and the source located on the ground. If the source is moved away from the head of the borehole, it is called "offset VSP". In "Reversed VSP", the receivers are located on the ground and the source is located in the borehole.

The VSP technique is seldom used alone, but is rather used to provide better interpretation of seismic reflection data. VSP allows accurate determination of one-

way travel time to various geologic units and analysis of attenuation and acoustic impedances, which are needed for construction of synthetic seismograms.

A brief introduction to this method is given in Cassel (1984).

14.6 Vibroseis

Vibroseis is a seismic method in which a vibrator is used as an energy source to generate a controlled wave train, instead of the usual impulsive sources (e.g. hammer, explosives, shot guns, etc.). This method requires recording of the source signal for reference.

A sinusoidal vibration of continuously varying frequency is applied during a sweep period typically lasting for several seconds (>10 s.). The sweep may start at either low, or high frequencies, and it can be linear or nonlinear. The recorded data, comprising many super positioned wave trains, has to be correlated with the source signal. The correlated record resembles a conventional seismic record such as results from an impulsive source.

15 Appendix G. Bibliography

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